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ABSTRACT

This student guidebook is designed for use with the study booklets in modules 30-31 included in the military-developed course on basic electricity and electronics. The course is one of a number of military-developed curriculum packages selected for adaptation to vocational instructional and curriculum development in a civilian setting. An introductory section gives an orientation to the guide and a safety notice. The remainder of the guide contains a summary and a progress check test for each lesson included in the modules. Where applicable, the guide contains instruction sheets for job programs and fault analysis (paper troubleshooting) and actual performance troubleshooting tests. (LRA)

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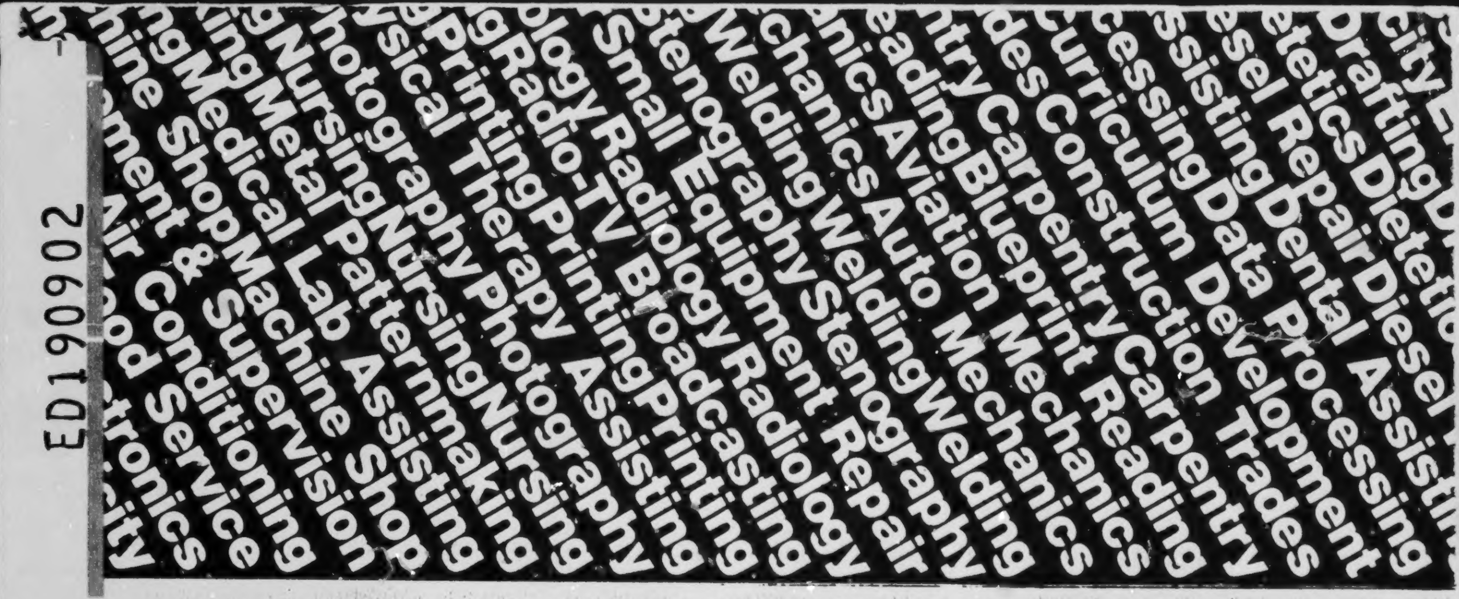
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CHIEF OF NAVAL EDUCATION AND TRAINING

CNTT-E-059

JULY 1980

Military Curricula for Vocational & Technical Education

BASIC ELECTRICITY AND ELECTRONICS.

MODULE 30. INTERMEDIATE POWER SUPPLIES.
MODULE 31. RF, IF, and VIDEO AMPLIFIERS.

STUDENTS GUIDE.

CE 026 587

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
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THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

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The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
The Ohio State University · 1960 Kenny Road · Columbus, Ohio 43210
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

PREPARED FOR

BASIC ELECTRICITY AND ELECTRONICS

CANTRAC A-100-0010

MODULE 30

INTERMEDIATE POWER SUPPLIES

MODULE 31

RF, IF AND VIDEO AMPLIFIERS

PREPARED BY

NAVAL EDUCATION AND TRAINING
PROGRAM DEVELOPMENT CENTER DETACHMENT

GREAT LAKES NAVAL TRAINING CENTER
GREAT LAKES, ILLINOIS 60088

STUDENT'S GUIDE

JULY 1980

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FOREWORD

This Student's Guide has been prepared to aid you in your progress through the self-paced Basic Electricity and Electronics Course. Many of the general instructions applicable to learning materials in earlier lessons will apply equally well in this module set. However, there have been some additions in this series which you should know about. The most notable changes are listed below and should be reviewed prior to beginning your study of the learning materials.

Paper Troubleshooting (fault analysis).

Performance Test Troubleshooting Procedures.

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SAFETY NOTICE

I- Introduction

In the performance of his normal duties, the technician is exposed to many potentially dangerous conditions and situations. No training manual or set of rules can make working conditions completely safe. However, it is possible for you as a technician to complete a full career without serious accident or injury if you are aware of the main sources of danger and if you remain constantly alert to these dangers. You must observe the proper precautions and practice the basic rules of safety consciousness until they become second nature to you.

All rating manuals contain some safety information. Of particular worth is the Standard First Aid Training Course, NAVEDTRA 91217-H. In addition, directives concerning safety are published by each major command on specific hazards and procedures falling under the cognizance of that command. The Chief of Naval Operations has issued a listing of specific precautions compiled by the Department of the Navy. This publication cross-references safety directives by subject matter and by the identifying designation.

Some of the major hazards you will encounter as a technician and some of the basic precautions that you must observe are listed in this section. Although many of these hazards and precautions are general and apply to all personnel, some of them are peculiar or especially applicable to personnel concerned with electronic maintenance.

II- General Safety Rules

Most accidents that occur in noncombat operations can be prevented if the full cooperation of personnel is gained and if care is exercised to eliminate unsafe acts and conditions. The following are some general safety rules that apply to personnel in all types of activities:

1. Report any unsafe condition or any equipment or material considered to be unsafe.

2. Warn others who are believed to be endangered by known hazards or by their failure to observe safety precautions.

3. Wear available protective clothing and use equipment that has been approved for safe performance of work or duty.

4. Report any injury or any evidence of impaired health occurring in the course of work or duty.

5. Exercise reasonable caution when any unforeseen hazard occurs.

III- Electrical Safety Precautions

Take time to be safe when working on electrical circuits and equipment. The following precautions, when carefully and thoughtfully observed, make the difference between a safe sailor and a sorry one:

1. Remember that electrical equipment frequently has more than one source of power. Opening main power supply switches will not necessarily "kill" all power to a given piece of equipment. Heaters and synchros, for example, may receive power from a remote source with no local switch or breaker available. Be certain that ALL power sources are de-energized before servicing ANY piece of equipment.

2. Remember that the 120 VAC line power supply voltage is not a low, relatively harmless voltage. It is the voltage that has caused more deaths in the Navy than any other.

3. Do NOT work alone with high-voltage circuits. Have a person (safety observer) who is qualified in administering first aid for electric shock present at all times. The man stationed nearby should also know the location of the circuits and switches controlling the equipment and should be prepared to secure the power switches immediately if anything unforeseen happens.

4. Equipment containing metal parts (brushes, brooms, and so forth) should not be used in an area within 4 feet of any high-voltage circuits or electrical wiring having exposed surfaces.

5. Keep clothing, hands, and feet dry at all times. When it is necessary to work in wet or damp locations, use a dry platform or wooden stool to sit or stand on and place a rubber mat or other nonconductive material on top of the wood. Use insulated tools and insulated flashlights of the molded type when required to work on exposed parts.

6. Do not wear loose or flapping clothing. The use of thin-soled shoes with metal plates or hobnails is also prohibited. Safety shoes with nonconducting soles should be worn if available. Flammable articles, such as celluloid cap visors, should not be worn.

7. Before working on an electrical apparatus, remove all rings, wristwatches, bracelets, ID chains and tags, and similar metal items. Care should be taken that the clothing does not contain exposed zippers, metal buttons, or any type of metal fastener.

8. Use one hand when turning switches on or off.

9. Make certain that the equipment is properly grounded. Ground all test equipment to the equipment under test.

10. When measuring circuits of over 300 volts, do not hold the test probes.

IV- First Aid for Electric Shock

Electric shock is a jarring, shaking sensation, resulting from contact with electrical circuits or from the effects of lightning. The victim usually feels that he has received a sudden blow. If the voltage and resulting current are sufficiently high, the victim may become unconscious. Severe burns may appear on the skin at the place of contact. Muscular spasms may occur which cause the victim to clasp the apparatus or wire. As a result, the victim may go into shock and be unable to release his grip.

The following procedure is recommended for the rescue and care of electric shock victims:

WARNING

DO NOT ATTEMPT TO ADMINISTER FIRST AID OR COME IN PHYSICAL CONTACT WITH AN ELECTRIC SHOCK VICTIM BEFORE THE POWER IS SHUT OFF, OR, IF THE POWER CANNOT BE SHUT OFF IMMEDIATELY, BEFORE THE VICTIM HAS BEEN REMOVED FROM THE LIVE CONDUCTOR.

1. Shut off the power.

2. If power cannot be deactivitated, per Step 1, revove the victim immediately, observing the following precautions:

   a. Protect yourself with dry insulating material.

   b. Use a dry board, belt, dry clothing or other available nonconductive material to free the victim (by pulling, pushing, or rolling) from the power carrying object. DO NOT TOUCH the victim.

3. Immediately after removal from the power-carrying object, determine whether or not the victim is breathing.

4. If the victim is breathing, keep him lying down in a comfortable position and loosen the clothing about his neck, chest, and abdomen so that he can breathe freely. Protect him from exposure to cold, and watch him carefully. If the victim is not breathing, apply artificial respiration without delay, even though he may appear to be lifeless. Do not stop artificial respiration until medical authority pronounces the victim beyond help.

5. Keep the victim from moving about. In this condition, the heart is very weak, and any sudden muscular effort or activity on the part of the victim may result in heart failure.

6. Do not give stimulants or opiates. Send for a medical officer at once and do not leave the patient until he has adequate medical care.

For complete information on administering artificial respiration and treating burns, refer to the Standard First Aid Training Course.

HOW TO USE THE STUDENT'S GUIDE

These guides are designed for you to use, along with the learning materials contained in the Study Booklets for each module, and additional or enrichment materials where applicable, while you are taking this segment of the Basic Electricity and Electronics course. The guides are yours to keep and may be taken with you when you complete the training.

Take a minute now to read the Foreword, the Safety Notice, and the Orientation sections carefully before you begin to study the subject matter.

These guides contain a summary and a progress check test for each lesson you will study. You may use the summary as a preview of the lesson or, after completing study of the learning materials, as a review before taking the lesson test.

When you have studied the lesson and feel you understand it, and before taking the lesson test, you should take the progress check. Although it is a test, the progress check is not considered a part of the formal testing program because you administer it yourself. Its purpose is to help you determine whether or not you have mastered the lesson objectives.

For certain lessons, these guides also contain the information and instruction sheets you will need for the job programs and the fault analysis (paper troubleshooting) and actual performance troubleshooting tests which must be completed in order to show you have mastered the lesson terminal objectives.

V- Electrical Fires

In case of an electrical fire, the following steps should be taken:

1. De-energize the circuit.

2. Call the Station fire department if on a shore base; if aboard ship, call the OOD.

3. Control or extinguish the fire, using the correct type of fire extinguisher.

4. Make reports as required by local directives.

For combating electrical fires, use a CO2 (carbon dioxide) fire extinguisher and direct it toward the base of the flame. Carbon tetrachloride should never be used for firefighting since it changes to phosgene (a poisonous gas) upon contact with hot metal, and even in open air this gas creates a hazardous condition. The application of water to electrical fires is dangerous; and foam-type fire extinguishers would not be used since the foam is electrically conductive.

In case of cable fires in which the inner layers of insulation or insulation covered by armor are burning, the only positive method of preventing the fire from running the length of the cable is to cut the cable and separate the two ends.

ORIENTATION

STUDENT'S GUIDE

JULY 1980

COURSE MISSION

The mission of this course is to train personnel who are ordered to specified A schools to demonstrate the applied skills and knowledges of basic electricity and electronics that have been designated by each of the schools to be entry-level prerequisites.

The terminal objectives for Modules 30 through 34 of this course are listed below. Unless otherwise stated, 100% accuracy is required.

When the student completes these modules, (s)he will be able to:

30.1.48 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state voltage multipliers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

30.2.49 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a complete regulating device when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

30.3.50 IDENTIFY the schematic diagrams, component functions, and operational principles of SCR power supply circuits, including the relationship between the conduction time of an SCR and the DC output voltage, by selecting statements from a choice of four.

30.4.51 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a regulated SCR power supply circuit when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

31.1.52 IDENTIFY basic operating characteristics of RF, IF and video amplifiers to include selecting definitions of terms, determining amplifier frequency response curve values, and determining amplifier voltage and power decibel gain, by selecting statements or values from a choice of four.

31.2.53 IDENTIFY the component functions and operating characteristics of RF amplifier circuits, including types of input and output transformer coupling, factors affecting and affected by Q in a resonant circuit, response characteristics of different classes of amplifier operation, and one method for testing the frequency response of an amplifier, by selecting statements from a choice of four.

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31.3.54 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a solid state IF amplifier when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

31.4.55 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state video amplifiers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

WHAT A SELF-PACED COURSE IS

If you have not been exposed to self-paced instruction, the following information is vital to your understanding the significant differences between conventional and self-paced instruction. For those of you who have experienced self-paced learning, the information following will identify how this particular self-paced course is different from others you may have been exposed to in the past. As you can see by looking around you, each of you has a private carrel rather than a desk facing the learning center instructor. Instead of giving a class assignment, the learning center instructor will give each of you a module containing instructional materials that will instruct you in what you need to learn and what materials are available for study. For example, in the module you may be told that you need to know what is meant by electricity and how an electric current runs through a solid wire. In addition, you will be informed that this information can be found in the summary, narrative, programmed instruction, or an audio visual presentation. At the end of each lesson topic there is a self-check test to help you determine when you have mastered the relevant concepts.

Once you know what resources are available to you, the decisions about which ones to use will be up to you. The other students in the learning center will not necessarily be doing the same thing at the same time. Each of you may choose the material and the method of presenting the material (medium) that is best suited to your particular needs or learning style. You will also decide when to take the progress checks and the module test. You do not have to take them when anyone else does. Once you have successfully "passed" the module test, you will be directed to the next module. At first, you may feel a little uneasy about having to make all these decisions instead of having someone else make them for you; but after a few days, it should become easy. The whole point of this instructional system is to allow you to become involved in the kind of decisions that are usually made by someone else, when, in reality, you are the one person in the best position to make them.

Read all instructions carefully. Many unnecessary mistakes are made and much confusion arises, when people do not read instructions or when they read them carelessly. Don't let yourself fall into that trap.

Learn well. In a group-paced course, it is possible to "slide by" without learning all the points in a lesson, because when the class moves on to the next lesson, everyone has to move. In this course, progress from one module to the next depends on your being able to meet the objectives of each module regardless of what anyone else is doing. Therefore, it is to your advantage to learn the information well before you take any test.

Use what is available. In this course, there are at least two or more instructional media you can study. If you have studied one type of material and you still do not understand, try studying one of the other media. For instance, if you have read the narrative and do not understand what it is all about, try the programmed sequence or the audio visual presentations. If you have tried alternative materials and still do not understand, ask for help.

Compete against yourself. You are not competing against any other student. It does not matter how well or how fast others achieve. Set your goals. This course is similar to mountain climbing: it is you against the mountain. When you get to the top, you will know that you met the challenge and won.

WHAT'S AVAILABLE AND HOW TO USE IT

I- The Learning Center

Your study area has been designed to provide as much privacy and convenience as possible. All the materials you will need are located at or near your assigned carrel. You will be able to read and study, view audio-visual programs, take tests, and perform job programs and performance tests entirely within the 30 Series learning center.

II- Written Materials

The Study Booklet, one for each module, contains the three major forms of presentation of each lesson. You should begin each lesson by reading the Overview and List of Study Resources. Then select and use one, all, or a combination of the following forms in order to master the knowledge portion of the lesson:

1. Summary. The summary is a condensed version of the lesson, the same one found in the Student Guides. You can quickly read the summary to get an overall picture of what the lesson is all about. If you already have a knowledge of electronics, you may be able to go directly from the summary to the lesson progress check.

2. Programmed Instruction (P.I.) The P.I. presents the lesson in the greatest detail. The information is broken down into small steps, called frames. The student is required to make many responses and thus learns by doing.

3. Narrative. The narrative presents the lesson very much like textbooks you have studied in high school or college. The narrative is more detailed than the summary. It presents the lesson completely.

You are encouraged to try out all three of these forms of presentation and become familiar with them. In that way you will be able to choose the form of each lesson from which you can learn the material most efficiently.

III- Additional and Enrichment Materials

For most lessons, additional forms of presentation (such as sound-slide or video tape programs) and/or other written references are available to supplement the Study Booklet materials. A list of these can be found on the List of Study Resources page following the Overview for each lesson in the Study Booklet.

IV- The Progress Check

When you finish each lesson, take the lesson progress check, located in this guide. Check your answers against those provided. If you miss a question, references are provided to help you restudy the materials. You may take the progress check at any time you feel you are ready. In fact, you may feel free to look over the progress check even before you begin to study the lesson.

V- Job Programs

Many lessons include a job program. Each job program is a laboratory experiment related to the lesson; it is completed before taking the lesson test. The job program reinforces the written lesson and lets you see what you have learned in actual circuits and equipment. It also teaches skills and testing procedures you will need for those lessons which have an actual performance troubleshooting test.

VI- Information Sheets

Many lessons have special test equipment and/or troubleshooting associated with them. To help you understand these areas, information sheets have been included in the guide which provide special instructions about this material.

FAULT ANALYSIS
(Paper Troubleshooting)

Many of the lessons in the 30 series have fault analysis exercises. These paper troubleshooting problems have been designed to help you think about possible solutions to given troubleshooting symptoms. The problems in these exercises are for actual circuits which you will be troubleshooting on the performance test. You should study the symptoms, and than look at the multiple choice answers. Based on your knowledge of the circuit, which you obtained from the Study Booklet and the job program, you should be able to select one of the choices which will produce the given set of symptoms.

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THE FORMAL TESTING PROGRAM

There are three types of formal tests for the modules in the 30 Series. These are:

(1) knowledge (lesson) tests,

(2) fault analysis (paper troubleshooting) tests, and

(3) performance troubleshooting tests.

All tests are assigned by the computer. Knowledge and fault analysis tests are computer graded. Performance tests are graded by the lab instructor.

Assigned knowledge (lesson) and fault analysis tests will be issued to you by the Learning Center Instructor. Knowledge tests measure achievement of objectives related to material presented in the summary, narrative and P.I.. Knowledge tests should be taken only after mastery of the progress check and completion of the job program, if applicable.

Fault analysis tests measure the ability to think through actual problems related to the circuit or equipment studied in the lesson. They also provide mental practice for the performance test.

Performance tests are actual troubleshooting encounters on prefaulted circuit boards issued by the lab instructor. You should not attempt a performance test until you have successfully completed both a fault analysis test and a practice performance test. Practice performance tests are assigned by the computer before the actual performance test is assigned, but they are not part of the formal testing program. Both practice and actual performance tests are graded by the lab instructor, who feeds the results into the computer.

SUMMARY
LESSON 1

Voltage Multipliers

In previous lessons you learned how voltages are increased by the use of a transformer. You also learned that when voltages are increased there is a corresponding decrease in the current output.

This lesson describes another method for increasing voltages. The method is called voltage multiplication and the circuits which accomplish the multiplication are called voltage multipliers. Voltage multipliers are designated as doublers, triplers, or quadruplers depending on the ratio of the output voltage to the input voltage.

Voltage multipliers are used to develop high DC voltage where there is a low current requirement. The most common use of voltage multipliers is to provide DC voltage for the anode of a cathode-ray tube (CRT). Output of voltage multipliers range from one thousand to thirty thousand volts. The actual voltage depends on the equipment application and size of the CRT.

Although the input for a voltage multiplier could be direct from the line, or power source, this is not usually the case for military electronic equipment. Most military equipments use transformer inputs since the transformer isolates the equipment from the line and thereby reduces the shock hazard.

Voltage multipliers are made up of voltage rectifiers which you are already familiar with. The rectifiers may be either full-wave or half-wave, depending on the circuit requirements. You recall that full-wave rectifiers are used when better voltage regulation is needed and that full-wave rectification results in a reduction in the output ripple amplitude and an increase in the ripple frequency.

The schematic shown in Figure 1 is that of a half-wave voltage doubler. Close examination and study of the schematic will reveal that the doubler is in fact made up of two half-wave voltage rectifiers. C1 and CR1 make up one rectifier and C2 and CR2 the other.

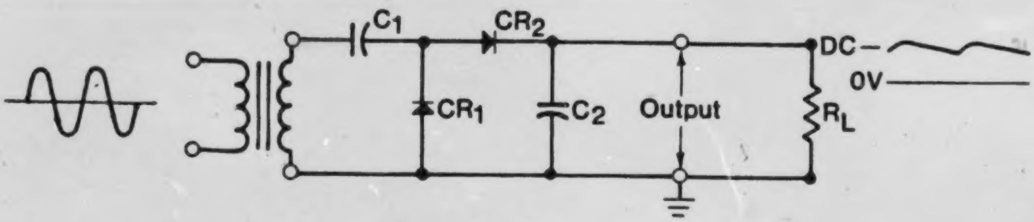


figure 1

HALF-WAVE VOLTAGE DOUBLER

When the top of the secondary winding of the transformer is negative, CR1 is forward biased, allowing C1 to charge to the peak value of the input voltage or 200 volts. When the top of the secondary winding of the transformer becomes positive, CR2 is forward biased and CR1 is reverse biased. At this time a series circuit exists consisting of C1, CR2, C2 and the secondary of the transformer. The secondary voltage of the transformer now series aids the voltage on C1 and results in a pulsating DC voltage of 400 volts as shown by the wave-form.

If you do not understand how a half-wave voltage doubler works after studying the schematic in Figure 1 and reading the explanation, you should consider an alternate mode of instruction. This lesson is also covered by narrative, programmed instruction, and tape/slide.

Figure 2 shows the schematic for a half-wave voltage tripler.

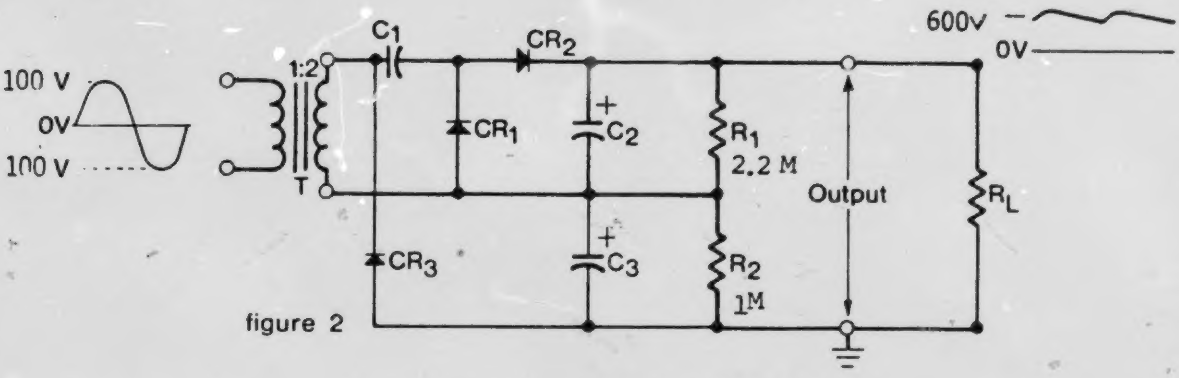


figure 2

HALF-WAVE VOLTAGE TRIPLER

The circuitry for the tripler is identical with that of the doubler except for the addition of C3, CR3, and R2. Considered separately, these components function as a half-wave rectifier. When the top of the secondary of the transformer is negative, CR3 is forward biased and functions as a closed switch. This allows both C1 and C3 to charge to a peak voltage of 200 volts. When the top of the transformer secondary is positive, C2 is charged to 400 volts as a result of the voltage doubling of the transformer secondary and C1. C2 and C3 now function as series aiding capacitors and discharge with a resultant voltage of 600 volts across the resistive load R_L. Note that the values of R1 and R2 are proportional to the voltages of C2 and C3, or in this case, a 2 to 1 ratio. Study the schematic to make sure you understand how the voltage tripler works.

The schematic shown in Figure 3 is that of a full-wave voltage doubler.

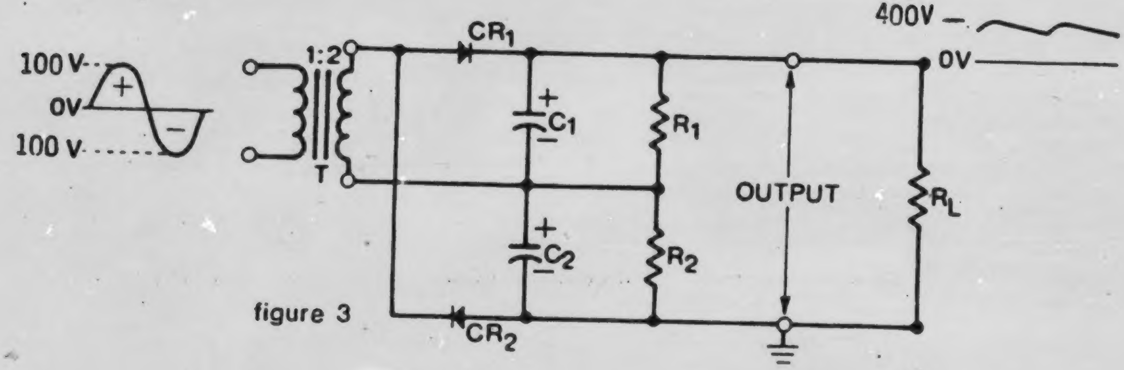


figure 3

FULL-WAVE VOLTAGE DOUBLER

When you examine the schematic you see that the circuit is in fact made up of two half-wave rectifiers. These rectifiers function as series aiding except in a slightly different way. During the alternation when the secondary of the transformer is positive at the top, capacitor C1 charges to 200 volts through CR1. Then, when the transformer secondary is negative at the top, C2 charges to 200 volts through CR2. R1 and R2 are equal value balancing resistors which stabilize the charges of the two capacitors. Resistive load R_L is connected across C1 and C2 so that it receives the total charge of both capacitors. The output voltage is +400 volts when measured at the top of R_L or point "A" with respect to point "B". If the output is measured at the bottom of R_L it is -400 V. Either way the output is twice the peak value of the AC secondary voltage. As you can see the possibilities for voltage multiplication are almost limitless.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 1

Voltage Multipliers

TERMINAL OBJECTIVE(S):

30.1.48 When the student completes this lesson, (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state voltage multipliers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions. 100% accuracy is required.

ENABLING OBJECTIVE(S)

When the student completes this lesson (s)he will be able to:

30.1.48.1 IDENTIFY the purpose of voltage multipliers, by selecting the correct statement from a choice of four. 100% accuracy is required.

30.1.48.2 IDENTIFY the schematic diagrams of half and full-wave voltage doubler and tripler circuits by selecting the correct name or diagram from a choice of four. 100% accuracy is required.

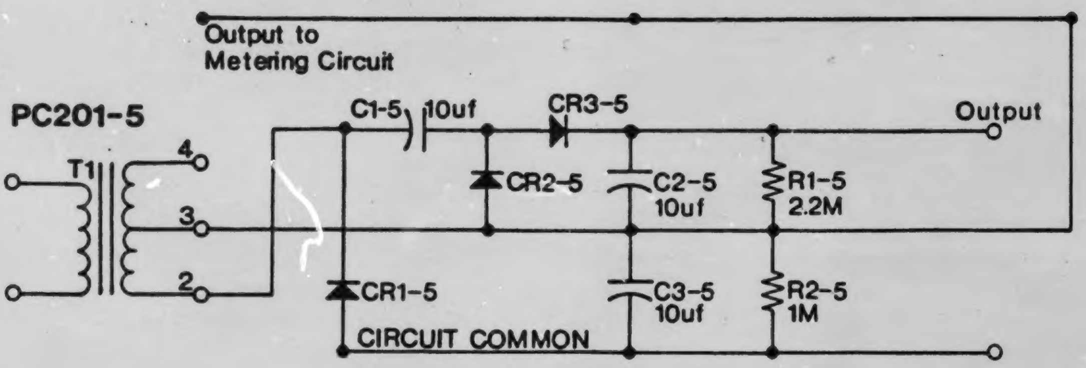
30.1.48.3 IDENTIFY the functions of components and circuit operation of half and full-wave voltage doubler and tripler circuits by selecting the correct statement from a choice of four. 100% accuracy is required.

30.1.48.4 CALCULATE voltage values for a given voltage multiplier circuit by selecting the correct value for a given output or component from a choice of four. 100% accuracy is required.

PROGRESS CHECK
LESSON 1

Voltage Multipliers

USING THE SCHEMATIC DIAGRAM SHOWN BELOW, ANSWER QUESTIONS 1 THROUGH 7.


Output to
Metering Circuit
PC201-5
T1
4
3
2
C1-5
10uf
CR3-5
CR2-5
C2-5
10uf
R1-5
2.2M
Output
CR1-5
C3-5
10uf
R2-5
1M
CIRCUIT COMMON

1. Select the correct input voltage to the multiplier.

   a. AC
   b. DC
   c. Rectified AC
   d. Rectified DC

2. When voltages are increased through the use of voltage multipliers, current ________A________ and power ________
   increases, decreases, remains the same increases
   ________B________
   decreases, remains the same.

	A	B
1.	increases	increases
2.	decreases	remains the same
3.	remains the same	decreases
4.	decreases	decreases

3. What polarity of the voltage observed at terminal 2 of T1 would cause C1-5 to charge?

   a. Positive
   b. Negative

4. Which component charges to twice the peak value of the input voltage?

   a. C1-5
   b. C2-5
   c. C3-5

5. What is the ratio of the voltage across C3-5 to the voltage across C2-5?

   a. Twice
   b. One-third
   c. One-half
   d. Three times

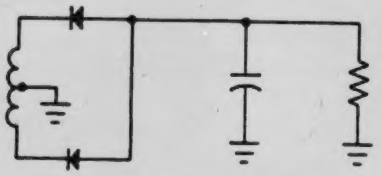
6. Select the correct statement which will determine when CR3-5 will conduct.

   a. CR1-5 is conducting.
   b. CR2-5 is conducting.
   c. C2 -5 is discharging.
   d. Pin 2 of T1 is positive.

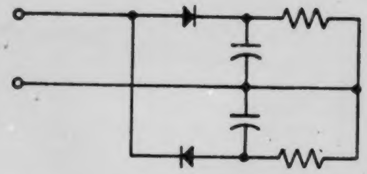
7. What is happening in the circuit when C1-5 is discharging. The voltage across:

   a. C2-5 will double.
   b. C3-5 will double.
   c. The output will double.
   d. C1-5 will double.

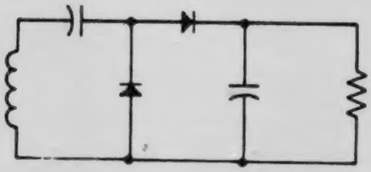
REFER TO THE SCHEMATIC DIAGRAMS BELOW TO ANSWER QUESTIONS 8 AND 9.



a



b



c

8. Which schematic diagram represents a half-wave voltage doubler?

   a.
   b.
   c.

9. Which diagram represents a full-wave voltage doubler?

   a.
   b.
   c.

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY AND FEEL READY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH THE LEARNING CENTER INSTRUCTOR UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

INFORMATION SHEET
LESSON 1

Digital Multimeter

In your previous experiments, when voltage or resistance was measured, a VOM was used. It is a very handy and common instrument for this purpose, but it has some disadvantages. A VOM's indication will vary from user to user. When taking a reading with the VOM, the angle at which you view the meter will make a difference in the interpretation of the reading. This viewing angle difference is called parallax error.

Another problem affecting the accuracy of a meter is the number of units represented by each graduation on the meter face. In some cases the distance between graduations could stand for hundreds of units of measurement. A good example of this is the left hand portion of the resistance scale where there is as much as 1000 ohms represented in 1/8 inch of space.

A more accurate instrument for measuring voltages, and resistances, is the digital multimeter (DMM). It uses a digital readout that does away with parallax error and the problem of the number of units represented by the graduations. The DMM also has a high input impedance (approximately 10 megohms), which minimizes loading effects caused by standard VOM's. This information sheet will describe the functions of the controls and give examples of how to take voltage and resistance measurements. We will use, in this school, the CCUH-8000A Digital Multimeter as a representative digital multimeter.

ENERGIZING DIGITAL MULTIMETER:

Refer to Figure 1 for the locations of controls discussed in the following paragraphs.

1. Attach the power cord to the POWER input connector. (1)

2. Depress green POWER ON switch (2) to the "on" position and ensure that the READ OUT (3) is lighted.

You are now ready to use the digital multimeter for voltage and resistance measurements.

VOLTAGE MEASUREMENTS

1. The CCUH-8000A is capable of measuring AC and DC voltages up to 2000 volts. The CCUH-8000A can have up to 1200 VDC or 1200 VRMS on all 5 DC scales and up to 1200 VRMS on the 20, 200 or 1200 V ranges and 500 VRMS on the 200 MV and 2V ranges. These voltages are overrange voltages and can be applied continually without damage to the unit. With the use of a special high voltage probe, the voltage range can be extended up to 40 kilovolts.

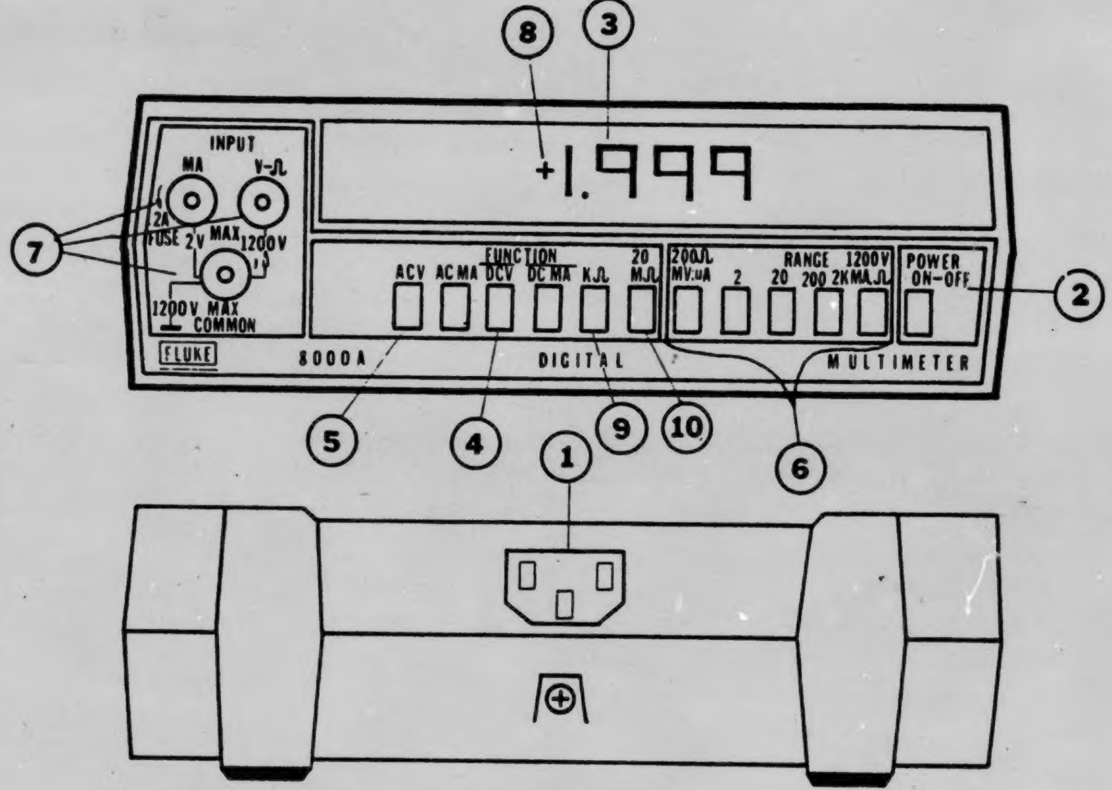

8
3
INPUT
MA
V-Ω
+1.999
2A
FUSE
2V
MAX
1200V
1200V MAX
COMMON
7
FUNCTION
ACV
AC MA
DCV
DC MA
KΩ
20
MΩ
200Ω
MV.uA
RANGE
2
20
200
2K
1200V
MA.Ω
POWER
ON-OFF
2
FLUKE
8000A
DIGITAL
MULTIMETER
5
4
9
10
6
1

Figure 1

DIGITAL MULTIMETER

2. To measure voltage on the CCUH-8000A, first press either the DCV (4) or ACV (5) function switch. This places the instrument in either the DC voltage mode or the AC voltage mode.

3. Select the full scale voltage range desired (200MV, 2, 20, 200, or 1200) pressing the correct RANGE switch (6).

4. Connect the voltage to be measured to the INPUT terminals (7). The DC range has an automatic POLARITY INDICATOR (8) that indicates whether the DC voltage being measured is positive or negative.

5. The display is a direct readout of the measured voltage with the necessary polarity marks and the decimal point placed in the correct position.

RESISTANCE MEASUREMENTS:

1. The CCUH-8000A will measure resistances in six full scale ranges of 200 ohms, 2K, 20K, 200K, 2000K and 20 megohms

2. Select the kilohms function switch (9) for measuring resistances between 0 and 2000 kilohms and use the 20 megohms switch (10) for measuring resistances between 2 and 20 megohms.

3. In the kilohms position select the desired full scale range (200 ohms, 2K, 20K, 200K, or 2000K) by pressing corresponding RANGE switch (6). In the 20 megohms position, the range is fixed and is independent of the range switches.

4. Connect the resistance to be measured to the INPUT TERMINALS (7).

5. The display presented is a direct readout of the resistance value with the decimal point in the correct position.

With both the voltage and resistance functions, there is an overrange indication. The display will blink and indicate a full scale reading when the measurement being taken is beyond the capabilities of the range being used. To rectify the overrange condition simply shift to the next higher range until the indicator goes out.

The CCUH-8000A Digital Multimeter has many applications. For explanations concerning transistor testing and current applications, as well as other applications, refer to the Technical Manual for the CCUH-8000A Digital Multimeter.

JOB PROGRAM
FOR
LESSON 1

Voltage Multipliers

DO NOT ATTEMPT THIS JOB PROGRAM UNTIL
YOU COMPLETE THE INSTRUCTIONAL PROGRAM FOR LESSON 1

INTRODUCTION:

This job program is designed to provide you with "hands on" experience measuring voltages in voltage multiplier circuits. The program will also give you experience using the digital multimeter. Completion of the job program will give you a better understanding of voltage multipliers and help prepare you for the lesson test.

TERMINAL OBJECTIVE(S):

30.1.48 When the student completes this lesson, (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state voltage multipliers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions. 100% accuracy is required.

ENABLING OBJECTIVE(S):

30.1.48.5 MEASURE and COMPARE output voltages, waveforms and resistance in voltage multiplier circuits given a training device, circuit boards, test equipment and proper tools, schematic diagrams, and a job program containing references for comparison. Recorded data must be within limits stated in the job program.

SAFETY PRECAUTIONS

Observe all standard safety precautions. Beware of all exposed connections, an energized circuit may have dangerous voltages in it.

EQUIPMENT AND MATERIALS

1. NIDA 201 Power Supply
2. PC201-5 Printed Circuit Card
3. Oscilloscope
4. Digital Multimeter
5. 10X Probe (1)
6. NIDA 201 Power Supply Instruction Manual
7. Information Sheet Thirty-1
8. Schematic diagram PC201-5, Voltage Tripler

PROCEDURE

1. Energize and set the oscilloscope for single trace operation with an INTERNAL TRIGGER input.

2. Connect the 10X probe to CHANNEL "A" of the oscilloscope.

3. Energize and set the digital multimeter to read "DCV" on the "200" volt range.

4. Remove the top cover from the NIDA 201 Power Supply.

5. Install the PC201-5 card in the NIDA 201 Power Supply.

6. Plug in and energize the NIDA 201.

7. Push the DC/AC switch on the oscilloscope to "DC". Position the trace on the center line as a reference for measuring DC level.

8. Refer to schematic diagram fold out at the end of this job program (pg. 65).

9. All measurements will be made with reference to circuit common.

10. Connect the 10X probe to pin 2 of PC201-5. Observe and record in Figure 1 the waveform observed.

    a. The peak voltage of this waveform is ________ V_{pk}.

    b. The RMS value of this waveform is ________ VAC.

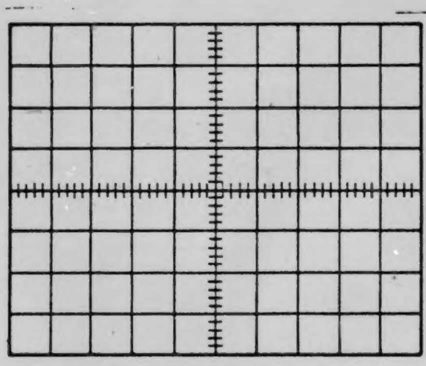


Figure 1

11. Using the oscilloscope in the "DC" position, observe and record in Figure 2 the voltage between the top of R1-5 and circuit common.

    a. What is the ripple frequency of the output voltage?__________

    b. Is the multiplier a half-wave or a full-wave multiplier?______

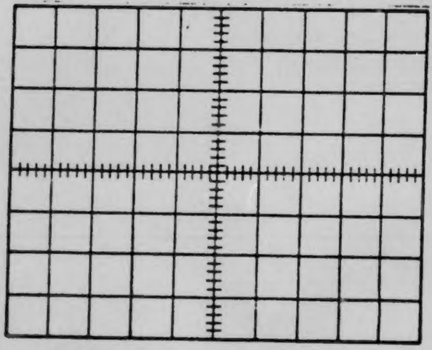


Figure 2

12. Using the digital multimeter measure and record the voltage between the top of R1-5 and circuit common.

    This voltage is ________ VDC.

13. This voltage is approximately ________ the peak input voltage.

    a. one-third
    b. twice
    c. three times
    d. the same as

14. Using the digital multimeter measure and record the voltage across C2-5.

    This voltage is __________ VDC.

15. This voltage is approximately ____________ the output voltage measured in step 12.

    a. one-third
    b. twice
    c. two-thirds
    d. the same as

16. Using the digital multimeter measure and record the voltage across C3-5.

    This voltage is ___________ VDC.

17. This voltage is approximately _________________ the output voltage measured in step 12.

    a. two-thirds
    b. three times
    c. the same as
    d. one-third

18. Using the color code, compare the resistance value of R1-5 to R2-5.

    a. What is the ratio of R1-5 to R2-5?

19. List the components in the schematic diagram of PCB 201-5 that operate as a voltage doubler ____________________________________

20. List the components in the schematic diagram of PCB 201-5 that operate as a half-wave rectifier __________________________________

21. What is the purpose of R1-5 and R2-5?_________________________________
____

22. Observe the front panel voltmeter of the PC201 power supply.

    a. What is the maximum range of the voltmeter?__________

    b. What value of voltage is being measured by the meter?_______

    c. What would happen to the meter movement if the full tripler multiplier voltage were applied to the meter?________________________
    ____

23. From the above it should be noted that the meter is measuring only one third of the tripler output.

24. Using the digital multimeter, measure the voltage at pin 7 to common and pin 18 to common of PC201-5 to verify your observations made in steps 22 and 23. This voltage is__________VDC.

NOTE: The discharge time of C2-5 and C3-5 is about 22 seconds which means that the printed circuit card PC201-5 should not be removed from the power supply until the power has been turned off for at least 30 seconds after you have completed this job program.

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON PROGRESS TEST. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH THE LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

INFORMATION SHEET
LESSON 1

Troubleshooting Power Supplies

Troubleshooting electronic circuits requires the application of skills and knowledges in a manner that is similar to solving a mystery novel, or "who done it" story. You must gather evidence and "clues" by physical methods. In electronics, this evidence gathering is accomplished by using your test equipment such as the oscilloscope and/or volt-ohm-milliammeter. When you have sufficient evidence, you use it in a logical, deductive manner to proceed from the known to the unknown. In a mystery, you determine the villain; in electronics you find the faulty component.

The following information is what you might call "hints for troubleshooting". These tidbits of information will aid you in analyzing the evidence you have at your disposal. They will help to remind you of significant relationships about certain facts. These proven aids will help to guide you to a logical conclusion.

What to look for:

1. When identical voltages are measured to common at two points in a circuit, the points are probably shorted together, or connected by a straight wire. See Figure 1.

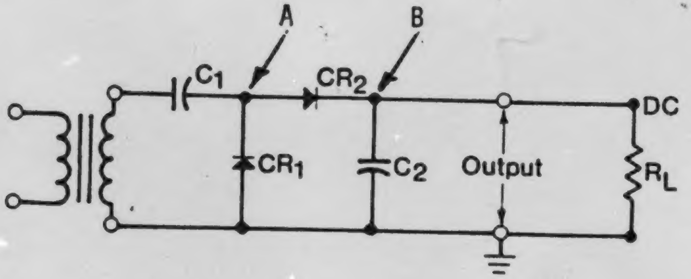


Figure 1

SYMPTOM

Voltage - "A" to ground equals
Voltage - "B" to ground

Conclusion: CR2 shorted
Confirm: Take resistance measurement across CR2 (be sure you remove power first)

2. The resistance of a connecting wire or foil on a printed circuit board is "Zero" ohms. See Figure 2.

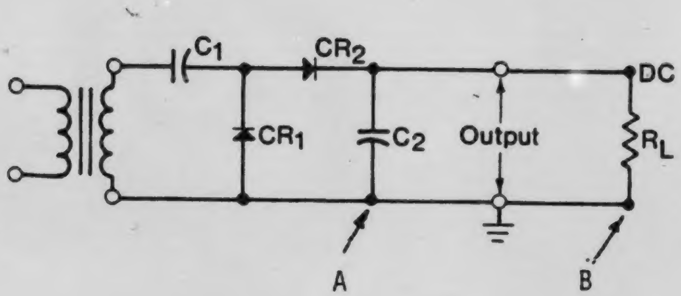


Figure 2

SYMPTOM

The resistance between points "A" and "B" is high.

Conclusion: The printed circuit board foil is open between points "A" and "B".

3. There are zero volts dropped across a component that does not have current through it. See Figure 3.

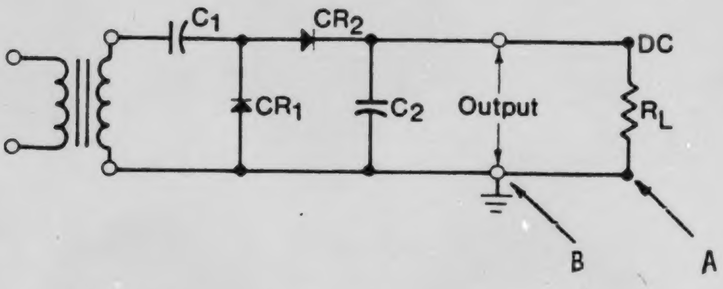


Figure 3

SYMPTOM

The voltage at point "A" is a high DC value.

Conclusion: R_L has no current through it. Open foil between points "A" and "B".

Confirm: Take resistance measurement between points "A" and "B".

FAULT ANALYSIS

(PAPER TROUBLESHOOTING)

FOR

MODULE 30, LESSON 1

NOW THAT YOU HAVE COMPLETED THE KNOWLEDGE SECTION OF THIS LESSON, YOU ARE READY FOR PAPER TROUBLESHOOTING.

THE COMPUTER WILL ASSIGN YOU A SET OF PAPER TROUBLESHOOTING PROBLEMS ON THE VOLTAGE TRIPLER CIRCUIT. THESE PROBLEMS WILL HELP YOU DEVELOP THE MENTAL SKILLS REQUIRED IN ACTUAL TROUBLESHOOTING. YOU WILL BE GIVEN SYMPTOMS OF A FAILURE AND CIRCUIT MEASUREMENTS THAT WILL ALLOW YOU TO IDENTIFY THE PROBLEM.

AFTER YOU COMPLETE THE PAPER TROUBLESHOOTING SECTION, THE COMPUTER WILL ASSIGN YOU A PRACTICE TROUBLESHOOTING PROBLEM ON A FAULTY PRINTED CIRCUIT BOARD.

REMEMBER THAT REFERENCE VOLTAGES, WAVEFORMS, AND A SCHEMATIC ARE CONTAINED IN THIS STUDENT GUIDE FOR YOUR USE IN BOTH PAPER AND ACTUAL TROUBLESHOOTING PROBLEMS.

TERMINAL OBJECTIVE:

When the student completes these modules, (s)he will be able to:

30.1.48 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state voltage multipliers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

ENABLING OBJECTIVE:

30.1.48.6 IDENTIFY the faulty component or circuit malfunction in a given voltage multiplier circuit, given a schematic diagram and failure symptoms, by selecting the correct fault from a choice of four. 100% accuracy is required.*

(* This objective is considered met upon successful completion of the terminal objective.)

OVERALL PERFORMANCE TEST INSTRUCTIONS

FOR

TROUBLESHOOTING PERFORMANCE TEST

INTRODUCTION:

Using the following six step troubleshooting procedure will aid you in determining which component is faulty. Depending upon the type of equipment you are troubleshooting some of the six steps may not be necessary and you should write "NA" in the blank if you think that this is the case. In the PC201-5 voltage multiplier, you will recall from the Job Program an output was taken from the top of R2-5 in order to protect the metering circuit. The actual output in practical voltage multipliers is taken across the two resistors so it is possible to indicate a proper voltage output on the front panel voltmeter in this case and still not have a proper output from the circuit. When measuring across a component in an energized circuit always connect the common lead first then use one hand to measure the voltage with the other probe.

EQUIPMENT:

1. NIDA 201 Power Supply
2. NIDA 201-5 Prefaulted Circuit Board
3. NIDA 207 Oscilloscope
4. 10:1 Oscilloscope Probe
5. Digital Multimeter
6. Simpson 260 Multimeter
7. 1 Pair of Multimeter Test Leads

INSTRUCTIONS:

1. Each student is required to determine the defective component in a prefaulted voltage multiplier. You will be allowed 45 minutes of troubleshooting time on the equipment.

2. Standard test equipment will be available to you in the form of an oscilloscope, a digital multimeter and a Simpson 260 multimeter. You will be expected to observe all safety precautions throughout the test. Improper use of test equipment in a safety violation will result in an automatic failure of the performance test. In that event, you will be counseled and given remedial training.

3. You will take a numbered position in the test room. After briefing by the Learning Center Instructor you will fill out the heading of the troubleshooting form. On a signal from the Learning Center Instructor you will then start the test. If at any time during the test you should require assistance, raise your hand. DO NOT LEAVE YOUR POSITION.

A Learning Center Instructor will assist you in your trouble. If the trouble is due to no fault of your own, you will not be penalized and a time extension will be given if necessary.

4. You must identify the faulty component or fault to pass this performance test.

5. If you do not understand these instructions, raise your hand and ask your learning center instructor. If you do understand these instructions, upon a signal from your learning center instructor you may now begin the performance test.

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SIX-STEP TROUBLESHOOTING PROCEDURES

FOR

TROUBLESHOOTING PERFORMANCE TEST

STEP ONE - SYMPTON RECOGNITION

1. The voltage multiplier is being used to supply a high voltage to a Cathode Ray Tube circuit. The Cathode Ray Tube is dark. Proceed to step two.

STEP TWO - SYMPTOM ELABORATION

1. Does the equipment energize?
    a. Front panel meters
    b. Power on light
    c. Neon light
        (1) Normal
        (2) Dim
        (3) Unlighted
2. What do the meters indicate?
    a. Normal
    b. High
    c. Low
    d. Zero
3. Are the front panel controls properly adjusted?
4. Is the equipment plugged into an outlet?

STEP THREE - LIST THE PROBABLE FAULTY FUNCTION(S)

1. There are three functions in a voltage tripler. Check the faulty functions.
    a. Primary circuit
    b. Half-wave rectifier.
    c. Voltage doubler.
2. In some cases all three functions will be listed and in other cases only one is required.

STEP FOUR - LOCALIZE THE FAULTY FUNCTION

1. Verify the probable faulty function by using your test equipment.
2. List the test points where voltages/waveforms were obtained.
3. Reference voltages and waveforms are listed in voltage/waveform charts.
4. Which function listed in step three above is the faulty function?

TROUBLESHOOTING PERFORMANCE TEST

STEP FIVE - LOCALIZE THE FAULTY CIRCUIT/COMPONENT

1. List the test points where actual voltages/waveforms were taken.
2. What circuit/component in the faulty function listed in step four is faulty?
3. If you have determined the faulty circuit but not the faulty component proceed to step six.

STEP SIX - FAILURE ANALYSIS

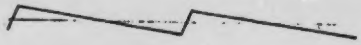
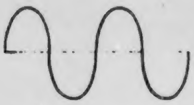
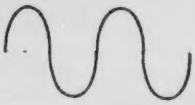
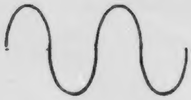
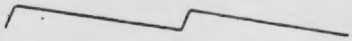
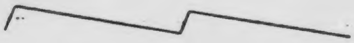
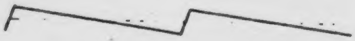
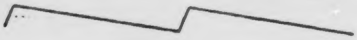
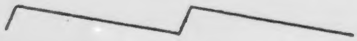
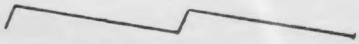
1. Secure the power and using the Simpson 260 take resistance checks.
   a. Check front to back ratios on diodes.
   b. Take continuity checks on printed circuit board foil.
   c. Capacitors can be shorted or open.
   d. Resistors can be open.
2. Explain in your own words why the component listed in steps five or six above would cause the symptoms listed in steps one and two of the six step troubleshooting procedure? Write your answer in the space provided below.

TROUBLESHOOTING WAVEFORM/VOLTAGE CHART

FOR

VOLTAGE TRIPLER PCB 201-5

THESE WAVEFORMS/VOLTAGES WERE MEASURED IN A PROPERLY OPERATING VOLTAGE TRIPLER. ALL MEASUREMENTS WERE TAKEN FROM THE INDICATED POINT TO COMMON. TOLERANCE IS +/- 5% WHEN TAKEN WITH A DVM AND +/- 20% WHEN USING A VOM (SIMPSON 260)

	OSCILLOSCOPE WAVEFORMS			DVM VOLTAGES
TP1	43 VDC			44.5 VDC
TP2			90 V P/P	44.5 VDC
TP3			90 V P/P	44.5 VDC
TP4			90 V P/P	89.0 VDC
TP5	43 VDC			44.5 VDC
TP6	130 VDC			134.5 VDC
TP7	130 VDC			134.5 VDC
PIN 7	43 VDC			44.5 VDC
PIN 11	43 VDC			44.5 VDC
PIN 18	43 VDC			44.5 VDC

SCHEMATIC DIAGRAM

VOLTAGE MULTIPLIER
(TRIPLER)

PC 201-5

P.P. 40, 41

SUMMARY
LESSON TWO

Transistor, Voltage and Current Regulators

This lesson covers circuits which are designed to regulate and maintain a constant voltage and current output and are called either voltage or current regulators depending on their purpose. Many are designed to maintain voltage or current outputs within plus or minus (±) 0.1 percent.

The two types of basic voltage regulators are series and shunt. The classification of the regulator depends on how it is connected in the total circuit. Series regulators are connected in series while the shunt type regulator is connected in parallel with the output load resistance. This is a basic concept that you should keep in mind as you complete this lesson.

A simple series type voltage regulator schematic is shown in Figure 1. Voltages are shown to help explain how the regulator works and enable you to understand the regulator's operation more readily.

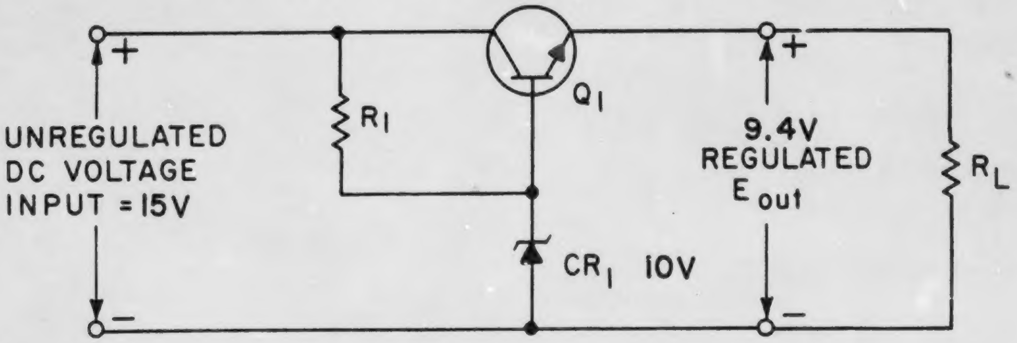


Figure 1

SERIES TYPE VOLTAGE REGULATOR

Q1 is used to regulate the voltage and functions in much the same way as a variable resistor would function. The main advantage of using the transistor is that it responds almost instantaneously to changes in input voltage or load current. The Zener diode CR1 blocks current flow until the applied voltage reaches or exceeds the Zener or break down voltage and provides a reference voltage for the base of Q1. Since Q1 is a series dropping device all current from the power supply flows through it. Q1 compensates for increases and decreases in input voltage and load current by changing its forward bias and resistance. With a 15 volt input voltage and a 10 volt Zener voltage, the regulated DC output is 9.4 volts. This results in a 0.6 volt voltage drop between the base and emitter of Q1.

Momentary increases or decreases in input voltage result in momentary changes in output voltage. Q1 compensates by increasing or decreasing its resistance, and the voltage drop changes in accordance with the amount of the transistors forward bias. In this way the transistor maintains a constant output voltage.

Again refer to the schematic. When the load current changes there is a change in voltage drop across RL. This results in a change in the voltage drop across Q1 and the transistor compensates for changes in load current in much the same way that it compensates for changes in input voltage. Before proceeding further make sure you understand how the circuit shown compensates for increases and decreases in input voltage and load current.

The schematic for a shunt type voltage regulator is shown in Figure 2. Except for the addition of resistor Rs the components of this circuit are identical with those of the series regulator. The other difference is the regulating device is connected in parallel with the load resistance. Note that the series dropping resistor Rs is connected in series with the load resistance and that CR1 and limiting resistor R1 function as a voltage divider to provide a constant DC potential to the base-collector of Q1.

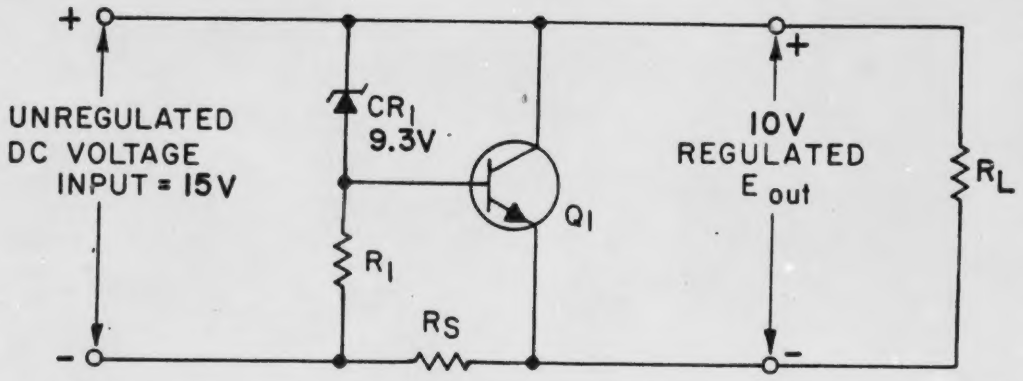


Figure 2

SHUNT TYPE VOLTAGE REGULATOR

With a 10 volt output voltage and Zener voltage of 9.3 volts the voltage drop across R1 is 5.7 volts as long as the circuit is providing a 15 volt input. Rs is the key component of this circuit because CR1 and R1 are connected in parallel with the load and any change in voltage is also reflected across R1. Any change in voltage drop across R1 results in a change in the forward bias of Q1 and therefore a change in the amount of current that is allowed to flow through the transistor. A good technique to help you understand and remember how the regulator compensates for changes in voltage is to substitute values that are different from those shown on the schematic and make the necessary mathematic computations.

Changes in load current are compensated for by Rs and Q1. For example, an increased load current results in an increased voltage drop across the series dropping resistor Rs. This action reduces the forward bias for Q1. Q1 compensates by increasing its resistance thereby reducing the amount of current that flows through it. Since less current flows through the transistor more current is allowed to flow through the load resistance. This returns the voltage drop across Rs to its former state. The components operate in the opposite way when the load current decreases.

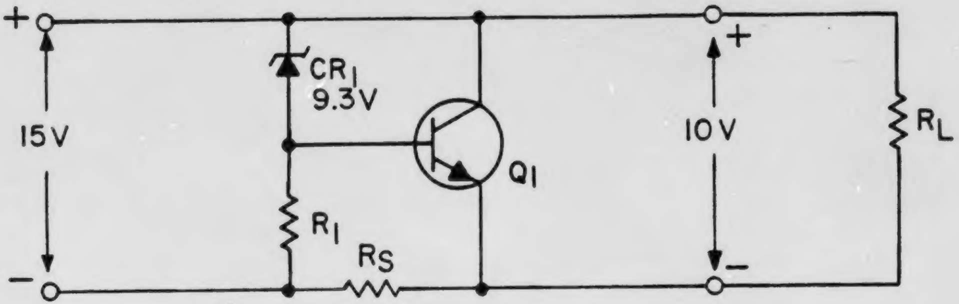


Figure 2

SHUNT TYPE VOLTAGE REGULATOR

A voltage comparator provides more precise regulation. The schematic for a typical comparator is shown in Figure 3.

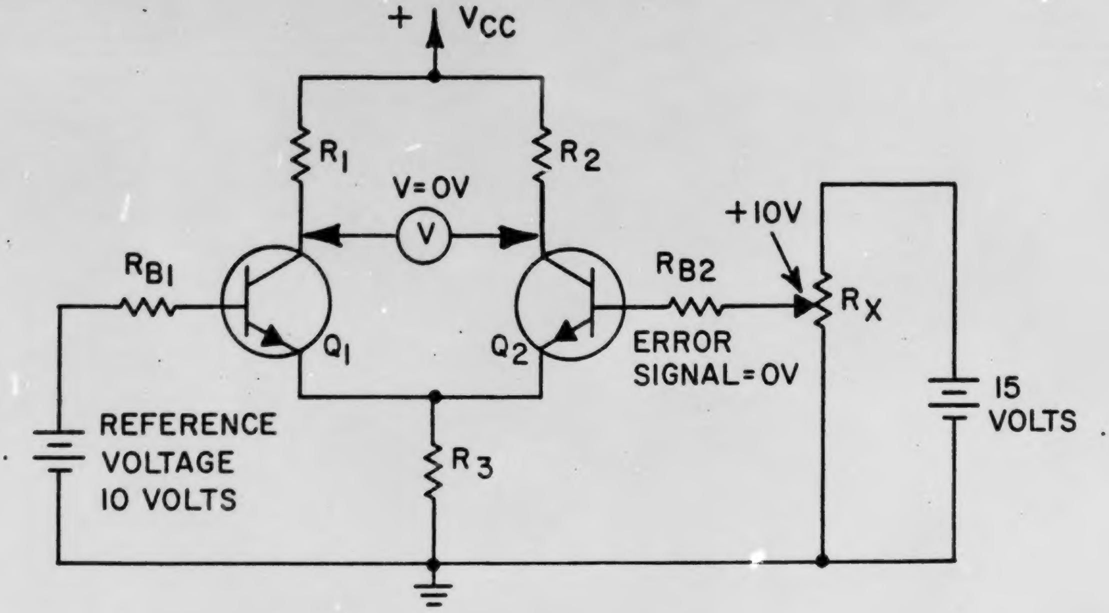

+ V_{CC}
R_1
R_2
V=0V
V
+10V
R_{B1}
R_{B2}
R_X
Q_1
Q_2
ERROR SIGNAL=0V
REFERENCE VOLTAGE 10 VOLTS
R_3
15 VOLTS

Figure 3

VOLTAGE COMPARATOR

The voltage comparator is sometimes called a differential amplifier because it amplifies the difference between the inputs to Q1 and Q2. These transistors are identical and load resistors R1 and R2 are also identical. So long as the voltage applied to the base of both transistors is equal the circuit remains balanced and has no output. The comparator functions because the collector voltages of the transistors are 180° out of phase with each other. In other words when the collector voltage of Q2 is more positive, the collector voltage of Q1 is less positive.

Figure 4 is the schematic of a circuit which you will encounter quite frequently and is called a Darlington type amplifier.

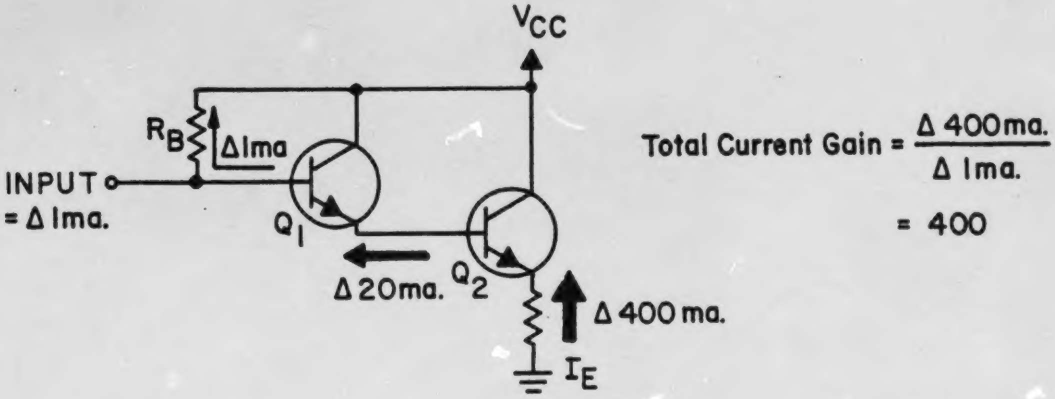


Figure 4

DARLINGTON AMPLIFIER

The advantage of the Darlington amplifier is high input impedance and high gain. The Greek letter Delta, which is represented by an equilateral triangle, is used to designate "a change of." Notice that the emitter output current of one transistor is the base current for the other transistor. This type of circuitry results in a current gain which is the product of the current gains in the individual transistors. In the example shown both transistors have a gain of 20. Therefore a 1 milliampere change at the base of Q1 will result in a total current output of 400 milliamperes. The possible combinations, of course, are endless.

The schematic shown in Figure 5 combines a voltage comparator and Darlington type amplifier.

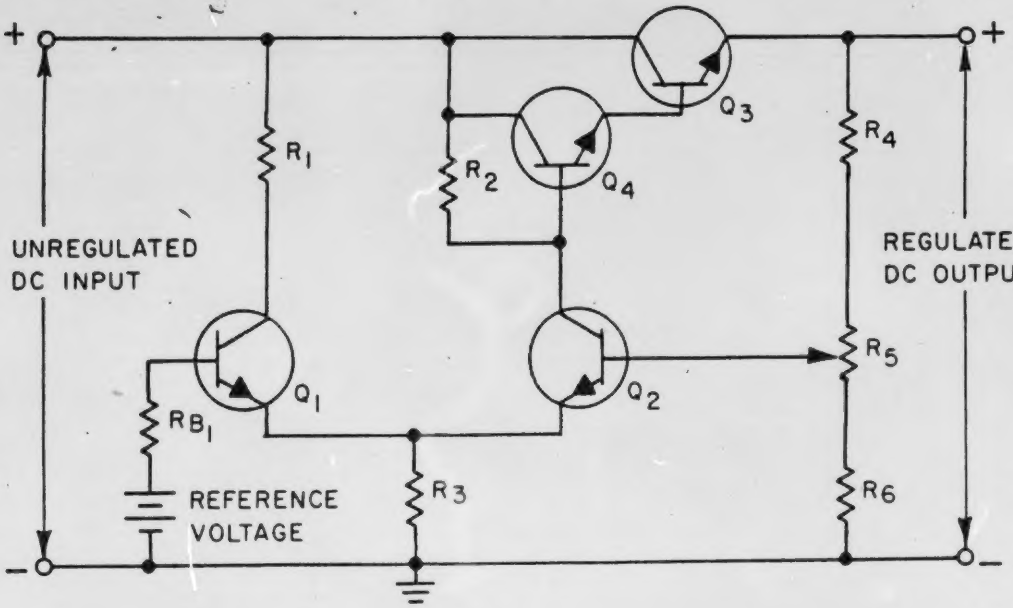


Figure 5

DARLINGTON AMPLIFIER + VOLTAGE COMPARATOR

Study the schematic to make sure you understand how the two circuits work together to maintain a regulated DC output. If you have difficulty understanding how these two circuits work together, you may wish to view the tape slide presentation for this lesson or study the programmed instruction or narrative form of this lesson.

Sometimes it is necessary to regulate current output. Circuits which are used to regulate current output are called current regulators. The schematic for a simple current regulator is shown in Figure 6. In many respects this circuit is identical with that of a series voltage regulator. The main difference is that an additional component has been added. This component, R1, is connected in series with the diode and senses current changes.

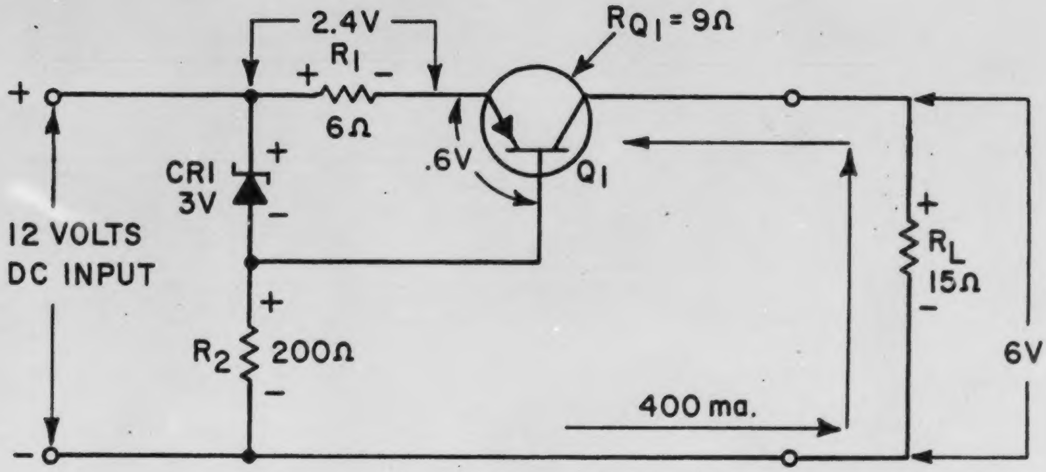


Figure 6

CURRENT REGULATOR

Voltages are shown on the schematic to help you understand how the current regulator operates. Study the schematic and note that the bias of Q1 is the difference between the voltages across Zener diode CR1 and R1. Since these components have opposite polarities the bias of the transistor is the difference between the two voltages.

Changes in the circuit load resistance causes a corresponding increase or decrease in current flow through the regulating device. Changes in load resistance are offset by corresponding changes in the transistor resistance. For example, a 5 ohm increase in the transistor resistance is the result of a 5 ohm decrease in the load resistance. Because the circuit is a current regulator the current remains constant. However, regulating the current in this way results in changes in the output voltage.

The schematic shown in Figure 7 is a current limiter. This type of circuit is used to prevent damage to delicate circuits which use semiconductor devices.

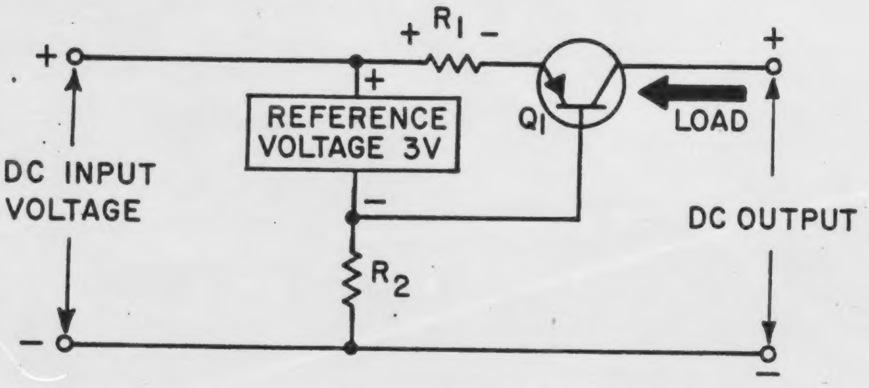


Figure 7

CURRENT LIMITER

Since the current limiter has a short response time it protects critical circuits against current overload. Notice that the schematic is identical with the schematic for the current regulator. The only difference between a current regulator and current limiter is the size, or value, of the series dropping resistor. The resistor which is used in the current limiter is smaller than the resistor which is used in the regulator. In order for the limiter to operate a reference voltage must be provided. This is shown in the schematic as a box. If you are unable to recall how circuits provide reference voltages refer to other parts of this lesson, the narrative, programmed instruction, or audio visual materials.

Changes in the transistor's bias and resistance compensate for changes in load current. Make sure you understand the basic operation of the limiter before proceeding further.

You should now be familiar with circuits which are used to regulate and control voltage and current outputs. As you complete the job program for this lesson you work with the NIDA model 201 power supply trainer. The circuits which are used in this trainer combine all the regulation circuits you have studied. When you become familiar with the NIDA equipment you will better understand how regulator devices operate together to accomplish complete regulation.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPICABLE), OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 2

Transistor, Voltage and Current Regulators

TERMINAL OBJECTIVE(S):

30.2.49 When the student completes this lesson, (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions of a complete regulating device when given a prefaulted circuit board, schematic diagram, necessary test equipment, and instructions. 100% accuracy is required.

ENABLING OBJECTIVES:

When the student completes this lesson, (s)he will be able to:

30.2.49.1 IDENTIFY the purpose of voltage and current regulators by selecting the correct statement from a choice of four. 100% accuracy is required.

30.2.49.2 IDENTIFY the schematic diagrams and operating characteristics of simplified basic series and shunt voltage regulator circuits by selecting the correct name or statement from a group of four. 100% accuracy is required.

30.2.49.3 IDENTIFY the schematic diagrams of practical series, shunt, and variable shunt voltage regulator circuits by selecting the correct name or diagram from a choice of four. 100% accuracy is required.

30.2.49.4 IDENTIFY the function of components and circuit operation of practical series, shunt, and variable shunt voltage regulator circuits by selecting the correct statement from a choice of four. 100% accuracy is required.

30.2.49.5 IDENTIFY the function of voltage comparator and Darlington amplifiers within voltage regulator circuits by selecting the correct statement from a choice of four. 100% accuracy is required.

30.2.49.6 IDENTIFY the schematic diagrams of voltage comparator and Darlington amplifier circuits by selecting the correct name or diagram from a choice of four. 100% accuracy is required.

30.2.49.7 IDENTIFY the function of components and circuit operation of voltage comparator and Darlington amplifier circuits by selecting the correct statement from a choice of four. 100% accuracy is required.

30.2.49.8 CALCULATE the current gain for a given Darlington amplifier circuit by selecting the correct value from a choice of four. 100% accuracy is required.

30.2.49.9 IDENTIFY the schematic diagram of practical current regulator and current limiter circuits by selecting the correct name of diagram from a choice of four. 100% accuracy is required.

30.2.49.10 IDENTIFY the purpose of current regulators and current limiters by selecting the correct statement from a choice of four. 100% accuracy is required.

30.2.49.11 IDENTIFY the function of components which make up the individual circuits within a complete transistor type voltage regulating device given a schematic diagram of the device.*

PROGRESS CHECK
LESSON 2

Transistor, Voltage and Current Regulators

1. Circuits which maintain a constant voltage or current are called ________.

   a. regulators
   b. multipliers
   c. filters
   d. controllers

REFER TO FIGURE 1 BELOW WHEN ANSWERING QUESTIONS 2 AND 3.

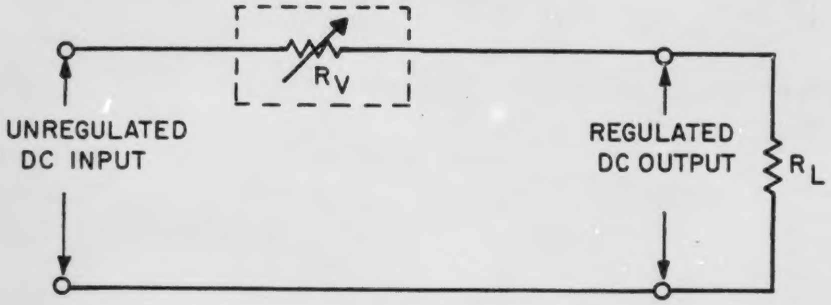


Figure 1

SERIES REGULATOR

2. If the input voltage decreases, what must be done to the value of Rv in in order to bring the output voltage back to normal?

   a. Increase
   b. Decrease
   c. Remain the same

3. If the load current decreases, the reason for this decreased load current is a/an

   a. increased input voltage
   b. decreased Rv
   c. increased RL
   d. decreased RL

4. Decreasing the resistance of Rv will compensate for a/an

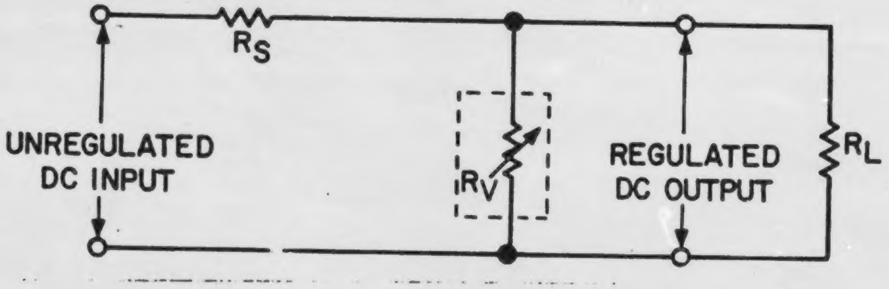

R_S
UNREGULATED DC INPUT
R_V
REGULATED DC OUTPUT
R_L

Figure 2

SHUNT VOLTAGE REGULATOR

a. increased input voltage or an increase in load current.
b. increased input voltage or a decrease in load current.
c. decreased input voltage or an increase in load current.
d. decreased input voltage or a decrease in load current.

REFER TO FIGURE 3 WHEN ANSWERING QUESTIONS 5 AND 6.

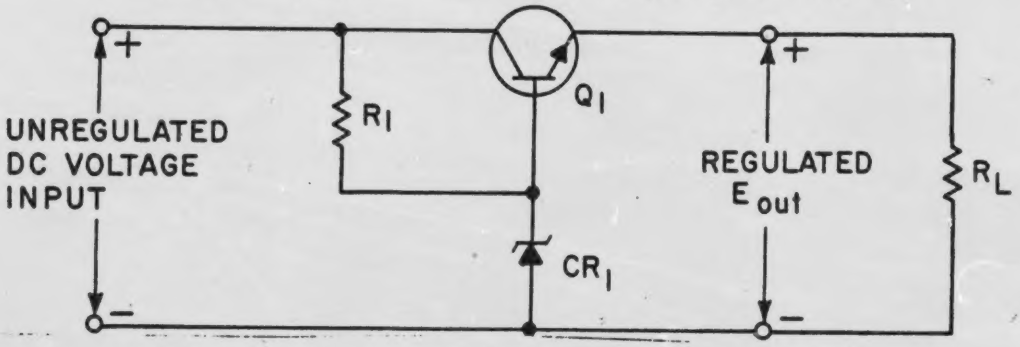

+
UNREGULATED DC VOLTAGE INPUT
−
R_1
Q_1
CR_1
+
REGULATED E_out
−
R_L

Figure 3

SERIES TRANSISTOR VOLTAGE REGULATOR

5. If the load current decreases, the value of the emitter voltage before regulation will

a. increase.
b. decrease.
c. remain the same.

6. If the input voltage increases, the

a. voltage across CR1 will decrease.
b. impedance of Q1 increases.
c. output impedance of RL will increase.
d. voltage across the base-collector junction decreases.

REFER TO FIGURE 4 BELOW WHEN ANSWERING QUESTIONS 7 AND 8.

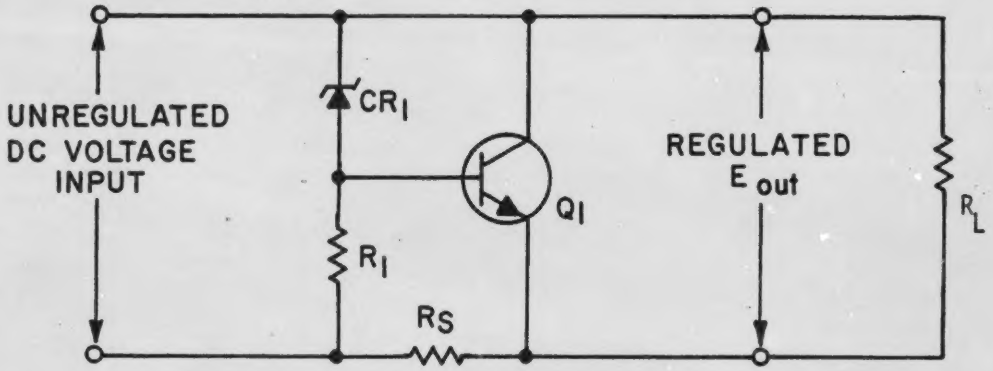


Figure 4

SHUNT TRANSISTOR VOLTAGE REGULATOR

7. The purpose of Zener diode CR1 is to maintain a constant

    a. collector-base voltage.
    b. regulated output voltage.
    c. emitter-base voltage.
    d. voltage across R1.

8. If the current flowing through RL increases,

    a. the voltage across Rs will decrease.
    b. transistor current will decrease.
    c. base-emitter voltage will increase.
    d. the voltage across CR1 will decrease.

9. The electronic circuit which makes better voltage regulation possible is called a

    a. series regulator.
    b. voltage doubler.
    c. shunt regulator.
    d. voltage comparator.

REFER TO FIGURE 5 BELOW WHEN ANSWERING QUESTIONS 10 AND 11.

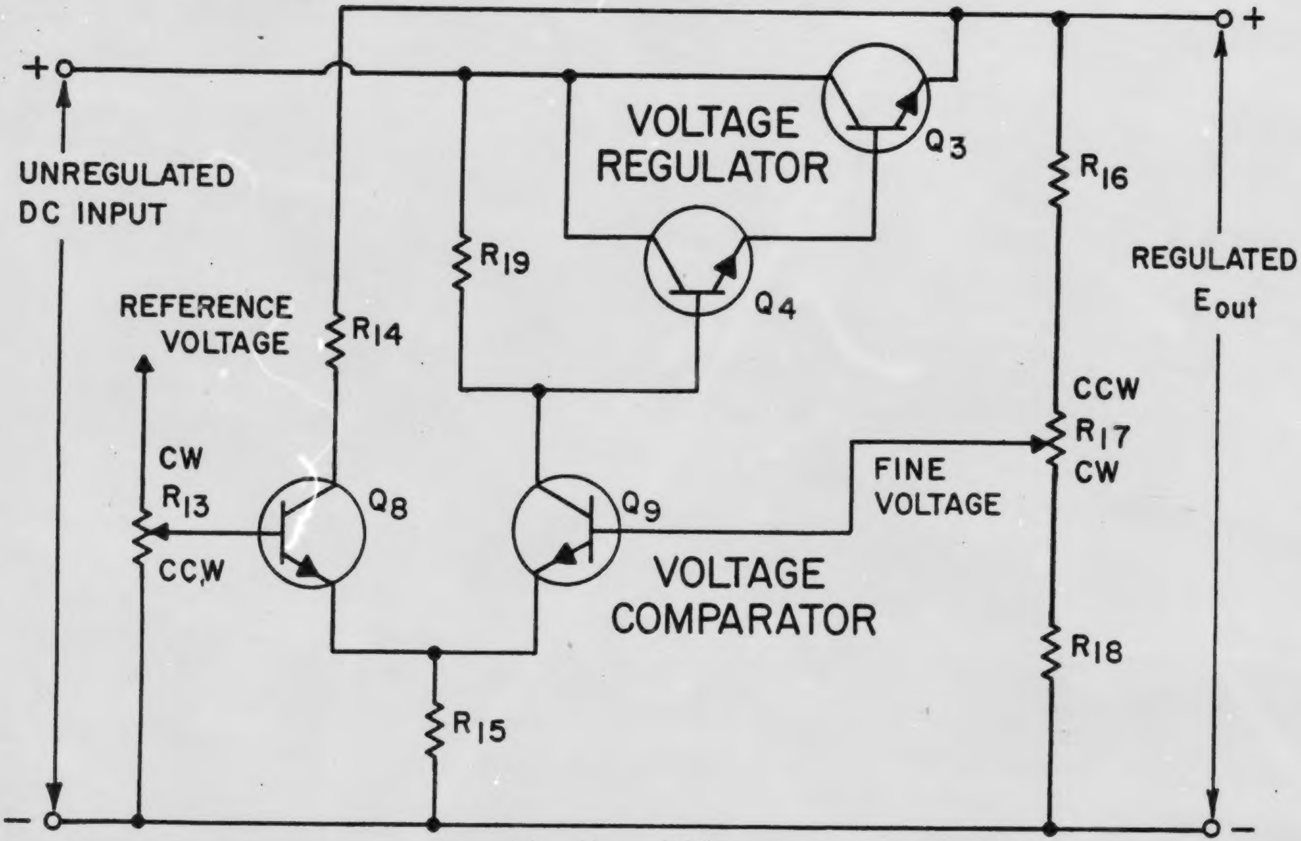

+
UNREGULATED DC INPUT
VOLTAGE REGULATOR
Q3
+
R16
R19
Q4
REGULATED E_{out}
REFERENCE VOLTAGE
R14
CCW
R17
CW
FINE VOLTAGE
CW
R13
CCW
Q8
Q9
VOLTAGE COMPARATOR
R18
R15
–
–

Figure 5

SHUNT DETECTED SERIES VOLTAGE REGULATOR

10. Any change in voltage from the collector of Q9 applied to the base of Q4 is known as the __________ signal.

    a. reference
    b. error
    c. applied
    d. correction

11. If the fine voltage control R17 is turned in a CCW direction, the

    a. base voltage of Q4 will increase.
    b. base-emitter voltage of Q9 will increase.
    c. regulated output voltage will increase.
    d. regulation ability of Q3 and Q4 will be exceeded.

12. A differential amplifier produces signals that are ________________ (equal/unequal) in amplitude and ________________ (in phase/out of phase) with each other.

    a. equal, in phase
    b. unequal, in phase
    c. equal, out-of-phase
    d. unequal, out-of-phase

REFER TO FIGURE 6 BELOW WHEN ANSWERING QUESTIONS 13 AND 14

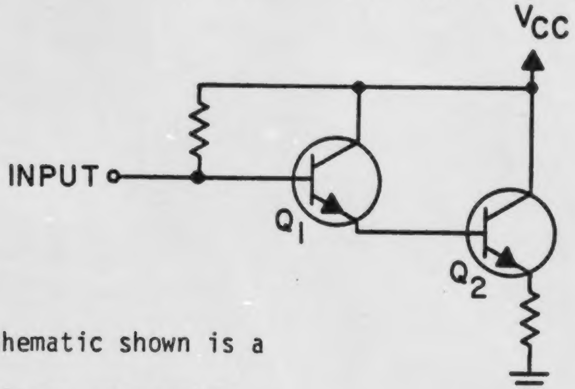


Figure 6

13. The schematic shown is a

    a. voltage comparator.
    b. shunt type series regulator.
    c. voltage doubler.
    d. Darlington amplifier.

14. If transistors Q1 and Q2 have gains of 20 and 30 respectively, what is the change in emitter current of Q2 assuming of a 2 milliampere input change at the base of Q1?

    a. 50 mA.
    b. 100 mA.
    c. 600 mA.
    d. 1200 mA.

15. The output gain of a Darlington type amplifier is the ________________ of the gain of the transistors which make up the amplifier.

    a. ratio
    b. sum
    c. difference
    d. product

16. Darlington amplifier circuit configuration requires that the ____________ of one transistor must be connected to the ____________ of the other transistor.

    a. base, collector
    b. collector, emitter
    c. emitter, base
    d. base, base

REFER TO FIGURE 7 WHEN ANSWERING QUESTIONS 17 AND 18.

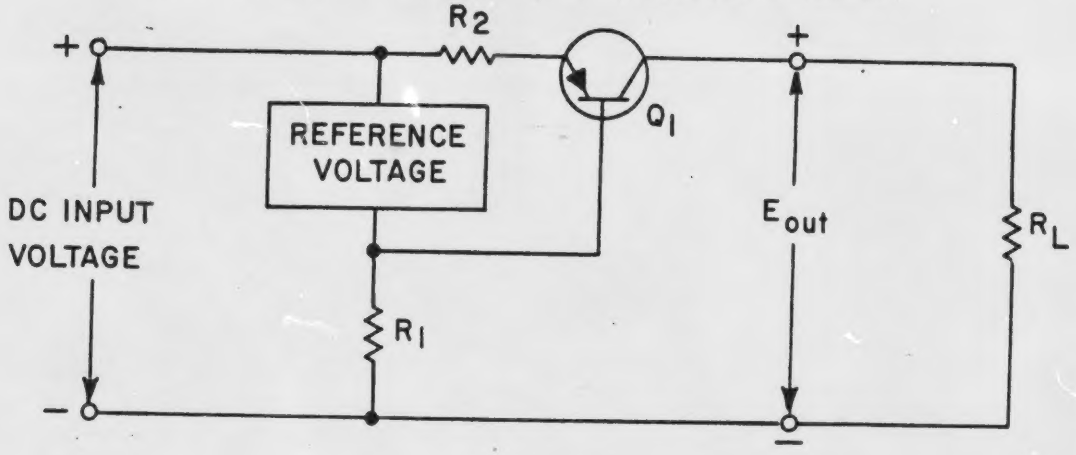


Figure 7

CURRENT LIMITER

17. The purpose of this circuit is to protect the equipment from

a. shorted components.
b. open circuited components.
c. excessive current.
d. excessive load impedances.

18. If the load current decreases, the voltage across R2 will

a. increase.
b. decrease.
c. remain the same.

19. Refer to the schematic diagram of the 201 power supply. The collector load impedance for Q9 is

a. Q6 and its associated circuitry.
b. Q4 of the series voltage regulator.
c. the differential amplifier Q8 and Q9.
d. series voltage regulator Q7 and CR5.

20. Refer to the schematic diagram of the 201 power supply. If the current through Q9 increases, the resultant current through Q6 will

a. increase.
b. decrease.
c. remain the same.

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

JOB PROGRAM
FOR
LESSON 2

Transistor Voltage And Current Regulators

INTRODUCTION:

This Job Program will demonstrate the various transistor voltage regulators and their operation. It is designed to permit you to prove to yourself the principles you studied on voltage regulators. Since the input voltage cannot be varied because this voltage is applied to the equipment from a receptacle, the Job Program will be oriented toward changes in load.

TERMINAL OBJECTIVE(S):

30.2.49 When the student completes this lesson, (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions of a complete regulation device when given a prefaulted circuit board, schematic diagram, necessary test equipment, and instructions. 100% accuracy is required.

ENABLING OBJECTIVE(S):

When the student completes this lesson, (s)he will be able to:

30.2.49.12 MEASURE and COMPARE current and voltage outputs in voltage and current regulator circuits given a training device, circuit boards, test equipment and proper tools, schematic diagrams and a job program containing references for comparison. Recorded data must be within limits stated in the job program.

SAFETY PRECAUTIONS:

Observe all standard safety precautions. Beware of all open and bare connections; an energized circuit may have dangerous voltages present. When connecting the digital multimeter to components, take care not to short probes to bare connections on the printed circuit board. Be EXTREMELY CAREFUL when measuring voltages on the emitter, base and collector of transistors; it is very easy to short these elements to the case of transistors which may very easily damage these transistors.

EQUIPMENT AND MATERIALS

1. NIDA 201 Power Supply
2. PC 201 Printed Circuit Board
3. NIDA 201L Load Box
4. Dual Banana Plug Cable
5. Digital Multimeter and Test Leads
6. NIDA 201 Power Supply Instruction Manual
7. NIDA 201 Schematic Diagram (Fold Out)

PROCEDURES

NOTE: STEPS 1 THROUGH 7 WILL SET UP THE NIDA 201 POWER SUPPLY FOR NORMAL OPERATION INTO A DUMMY LOAD. REFER TO THE SCHEMATIC DIAGRAM OF THE NIDA 201 POWER SUPPLY (FOLDOUT PG. 187).

1. Turn all front panel controls CCW.
2. Remove the top cover from NIDA 201 Power Supply.
3. Install the NIDA 201 printed circuit board in the Power Supply.
4. Connect one end of the dual banana plug cable to the NIDA 201 Power Supply output jacks, observing the proper polarity (the tab on the side of the plug to the ground connection). Connect the other end of the plug to the NIDA 201L load box again observing the proper polarity.
5. Set the load selector switch on the NIDA 201L load box to variable with the variable load set to "minimum load" and place the toggle switches for load 1 and 2 and load 3 to the up position with the series-parallel switch in the parallel position.
6. Plug in and energize the NIDA 201 Power Supply.
7. Rotate the coarse voltage control R13, fine voltage control R17 and current control R5 fully CW.

NOTE: STEPS 8 THROUGH 11 WILL SET THE CURRENT LIMITING VALUE FOR THE NIDA 201 POWER SUPPLY IN THIS JOB PROGRAM.

8. Turn variable load control on the NIDA 201L load box to maximum.
9. Push limit switch in and set current control R5 on the front panel to 1.5 A.
10. Release the current limit switch. You have now established the maximum amount of current that can flow in the circuit. DO NOT adjust this control anymore during this part of the Job Program.
11. Observe and record the front panel current and voltage from the front panel meters.______________Amps ___________VDC

NOTE: STEPS 12 THROUGH 14 WILL ESTABLISH THE REGULATED VOLTAGE RANGE FOR THE NIDA 201 POWER SUPPLY.

12. Very slowly rotate the variable load control on the 201L load box CCW.
    a. Is the voltmeter indication increasing/decreasing/or remaining the same?

       ____

    b. Is the voltage regulated or unregulated at this time?___________

13. Continue rotating the variable load control on the 201L load box CCW until the voltmeter indicates a steady voltage. Observe and record this voltage and current.

________________VDC. ________________Amps.

14. Rotate the variable load control on the 201L load box to minimum.

a. What has happened to the voltmeter indication?

(1) increased
(2) decreased
(3) remained the same

b. What has happened to the ammeter indication?

(1) increased
(2) decreased
(3) remained the same

c. What is the indication on the ammeter?____________________A.

d. Is the voltage being regulated at this time?____________Yes/No

e. What is the current range over which voltage regulation is taking place?

____________________A.

15. Set the variable load control on the 201L load box to mid-range. Set the coarse voltage control R13 to 15 VDC output on the front panel voltmeter.

16. Rotate the variable load control on the 201L load box for an indication of 0.6 A on the front panel ammeter. DO NOT touch the controls on the power supply for the remainder of this part of the Job Program.

NOTE: You will now analyze the operation of the series voltage regulator consisting of Q7, CR5, R13 and the associated circuitry. You will notice that when you decrease the load less current is required from the power supply and that when you increase the load more current is required from the power supply. You will prove that within limits the series voltage regulator will maintain the voltage across R13 and the outut voltage from the power supply constant over a wide variation in load.

17. Plug in and energize the digital multimeter. Connect the common probe to pin #1 of printed circuit board 201 using an alligator clip.

18. Measure and record the voltages present on the designated elements of Q7.

V_C = ____________VDC
V_B = ____________VDC
V_E = ____________VDC

19. Using the measurements you obtained in step 18, calculate the base-emitter voltage of Q7 ________________VDC.

20. Increase the variable load control on the 201L load box until the front panel ammeter indicates 1 ampere.

21. Measure and record the voltages present on the designated elements of Q7.

V_C = __________VDC
V_B = __________VDC
V_E = __________VDC

22. Using the measurements you obtained in steps 21, calculate the base-emitter voltage of Q7 ________VDC.

23. Decrease the variable load control on the 201L load box until the front panel ammeter indicates 0.2 amperes.

24. Measure and record the voltages present on the designated elements of Q7.

V_C = __________VDC
V_B = __________VDC
V_E = __________VDC

25. Using the measurements you obtained in step 24, calculate the base-emitter voltage of Q7 ____________VDC.

    a. What is the difference in the base-emitter voltages measured in steps 19, 22 and 25?__________________VDC.

    b. What happened to the output voltage on the front panel voltmeter? ________________ (increased/decreased/remained the same).

NOTE: You have now completed the evaluation of a series voltage regulator by increasing and decreasing the load. If, at this time, you do not understand what you have done, go back over this Job Program of the series voltage regulator until you thoroughly understand it.

The next circuit you will analyze is the differential amplifier. Since the inputs and outputs of this amplifier are not equal it is not a true differential amplifier but a modified version. Looking at the schematic you will notice that coarse voltage control R13 varies the base voltage of Q8. Notice that fine voltage control R17 varies the base voltage of Q9, whose output is applied to the base of Q4 and the collector of Q6.

The front panel fine voltage control R17 and the coarse voltage control R13 on the front panel are not external controls in actual equipment. You will be required in the equipments phase and in the fleet to measure and adjust these voltages for proper regulated indications. If not adjusted properly they cause problems in both radar and communications systems.

26. Set the front panel controls the same as you did in steps 7 through 10 of this Job Program.

27. Set the variable load control on the 201L load box to 0.6 amperes on the front panel ammeter.

28. Set the coarse voltage control R13 to indicate 15 VDC on the front panel voltmeter.

29. Reset the variable load control on the 201L load box to indicate 0.6 amperes on the front panel ammeter.

30. If the load increases, the impedance of Q3 and Q4 should decrease and the voltage across this impedance should decrease. Using the digital multimeter what is the present indication at pin #15?__________ VDC. What is the indication on the front panel ammeter? __________ A. What is the indication on the front panel voltmeter? __________ VDC.

31. Insert the probe of the digital multimeter into pin #15 and increase the load to 1.3 A.

    a. What is the digital multimeter indication?______________ VDC.

    b. What is the front panel voltmeter indication?__________VDC.

    c. What is the difference between step 31a and 31b?________VDC. (This voltage is V_{CE} for Q3)

    d. What happened to the impedance in step 31a and 31b?______. (increased/decreased/remained the same).

    e. Does this prove the statement in step 30?_________(Yes/No).

32. Leave the probe in pin #15 and decrease the load to 0.2 A.

    a. What is the digital multimeter indication?____________VDC.

    b. What is the front panel voltmeter indication?__________VDC.

    c. What is the difference between step 32a and 32b?________VDC.

    d. From the information obtained above, is the series voltage regulator operating properly?________________(Yes/No).

NOTE: You have completed your analysis of the modified differential amplifier and series voltage regulator Q3 and Q4 and determined that the circuits are operating properly. You did not see a difference in the output voltage on the front panel voltmeter because the error signal applied to the base of Q9 and the correction signal applied to the base of Q4 happen so fast that a voltmeter cannot detect the change. If you do not understand what you have done, go back over this part of the Job Program until you understand it.

The next circuit you will analyze is the current regulator Q6. You will prove that the current through Q6 will remain constant from minimum load to 1.3 amperes because the base-emitter voltage remained constant. Reviewing back to transistor theory you may remember that the base-emitter voltage controls the amount of current flow through a transistor and if this voltage remains constant then the current will be constant. THIS WILL BE YOUR PROOF.

33. Set variable load control on the 201L load box to minimum. Measure and record the voltages present on the designated elements of Q6.

V_C = __________VDC.
V_B = __________VDC.
V_E = __________VDC.

34. Set variable load control on the 201L load box to 1.3 amperes. Measure and record the voltages present on the designated elements of Q6.

V_C = __________VDC.
V_B = __________VDC.
V_E = __________VDC.

35. What is the base-emitter voltage in step 33? ____________VDC.

36. What is the base-emitter voltage in step 34? ____________VDC.

37. What does the information in steps 35 and 36 tell you about the current through Q6 as the load was increased from minimum to 1.3 amperes? __________________.

NOTE: So far, all the principles of voltage and current regulation you studied in the narrative, programmed instruction, summary, or tape/slide have been proven by you in this Job Program.

You will now analyze the operation of the current limiter consisting of Q1, Q2, R2, and R3. The purpose of this limiter is to protect the power supply from excessive currents.

38. Set the variable load control on the 201L load box to minimum.

39. Set all controls on the front panel of the power supply fully CW.

40. Set the variable load control on the 201L load box to maximum. Measure and record the voltages present at the indicated points in the circuit and calculate the voltage between the emitter of Q1 and the base of Q2.

R5 Set to	ER2	Pin #7 to Q2 base	VBE Q1 and Q2
CCW.	____VDC	________VDC	________VDC
0.3 A	____VDC	________VDC	________VDC
0.6 A	____VDC	________VDC	________VDC

a. Is limiting action taking place at each of the above settings?____ (Yes/No).

b. Are the transistors conducting with R5 fully CCW? (Yes/No).

C. Explain your answer to step 40b above.____________________
____
____

41. Return front panel current control R5 to its fully CCW position.

42. Very slowly rotate the front panel current control R5 CW until the ammeter just starts to indicate.

43. Measure and record the voltage between pin #12 and the base of Q2.____ VDC.

44. Is the current limiter operating properly at this time?____(Yes/No).

NOTE: You have completed your analysis of the current limiter. If you do not understand what you have done, go back over this part of the Job Program until you do understand it.

The last circuit you will analyze in this Job Program is the variable shunt voltage regulator. It is designed to be variable so that the voltage on the current limiter would vary as you changed the front panel current control R5 or as you changed the load. The important point to check here is that the output of the regulator will be held to within a 4 volt range depending upon the setting of R5.

45. Set the variable load control on the 201L load box to maximum, the front panel fine voltage control R17 and coarse voltage control R13 fully CW.

46. Set front panel current control R5 fully CCW.

47. Measure and record the voltage from pin #7 to the left side of R7 which is the emitter of Q5____________VDC.

48. Set front panel current control R5 fully CW.

49. Measure and record the voltage from pin #7 to the left side of R7 which is the emitter of Q5____________VDC.

a. What is the maximum voltage across Q5?______________VDC.

b. At what setting of R5 was the current through Q5 maximum?____ (CW/CCW).

c. At what setting of R5 was the current through Q5 minimum?____ (CW/CCW).

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON TEST. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

INFORMATION SHEET
LESSON 2

Transistor Troubleshooting

This information sheet is another in the series, and will help you to analyze data about a troubleshooting problem. This sheet is designed to remind you about significant relationships concerning transistors. These proven aids will aid you in arriving at a logical conclusion.

1. The voltages measured on individual elements of a transistor when a trouble occurs will primarily depend upon (1). The type of transistor (PNP or NPN) and (2). To what element the source voltage is applied, (emitter or collector).

2. Transistors may develop open or shorted junctions. It is quite difficult to open a transistor junction although in some cases, this will happen.

3. High power transistors rarely become leaky. In most cases they completely short, emitter to collector.

4. Low power transistors rarely completely short. They become leaky. Distortion occurs in the output.

5. If a coupling transformer, coil or tank capacitor should become detuned, for any reason, the output will be reduced and all DC voltages will be normal.

6. If a bypass capacitor should open, all DC voltages will be normal. The output may or may not be reduce in amplitude.

7. Open coupling capacitors will cause the output signal to be zero. All DC voltages will be normal.

8. An open emitter or cathode bypass capacitor will cause the output signal to decrease in amplitude (degeneration). All DC voltages will be normal.

NOTE: THE ABOVE STATEMENTS ARE GENERAL STATEMENTS AND APPLY TO ALL ELECTRONIC CIRCUITS. STATEMENTS #5, #6, #7 AND #8 ALSO APPLY TO VACUUM TUBE CIRCUITS.

9. When measuring voltages in a PNP transistor circuit with V_{CC} applied to the emitter, if $V_C=V_E$ and is approximately equal to the source voltage, look for an open in the collector circuit. In an NPN transistor with the source voltage applied to the collector. If $V_C=V_{CC}=V_E$ and is very low, look for an open in the collector circuit. See attached schematic diagram.

10. If $V_{CC}=0V$, look for an open in the power supply or battery circuit.

11. There are two conditions which would cause V_E to equal 0V, assuming that the emitter is not normally grounded by circuit design. An open B-E junction or an open base current limiting resistor. A shorted bias stabilizing resistor will also cause the above symptoms but this is very rare.

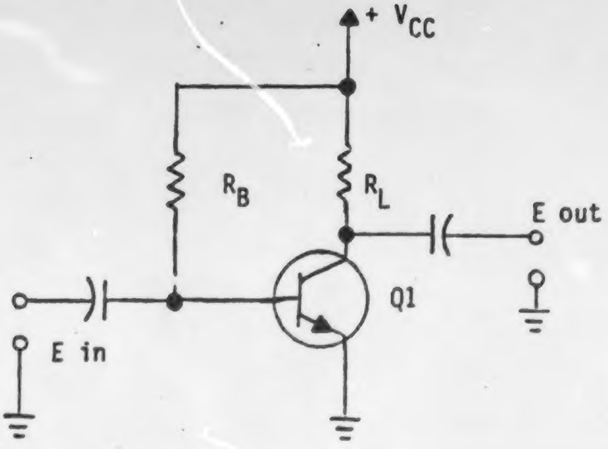
12. PNP-source applied to the emitter circuit. V_E is approximately equal to V_B and V_E is higher than normal with V_C equal to 0V, look for an open emitter resistor. If the B-E junction were shorted V_C would not equal zero. NPN-source applied to the collector circuit. V_E is approximately equal to V_B and V_C=V_{CC} with V_E higher than normal look for an open in the emitter circuit. See attached schematic diagram.

13. A leaky transistor will cause V_E to be higher than normal but V_C will not equal V_{CC} nor will V_C=0V as in statement 12.

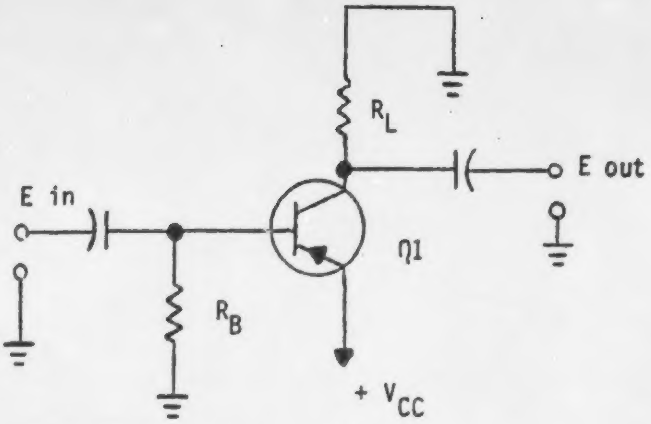
14. A zero voltage reading on the base indicates trouble in the base circuit regardless of the voltages measured on the emitter or on the collector.

Example #1

Symptom $V_C = 0V$


+ V_{CC}
R_B
R_L
E out
Q1
E in

Symptom $V_C = V_E = V_{CC}$

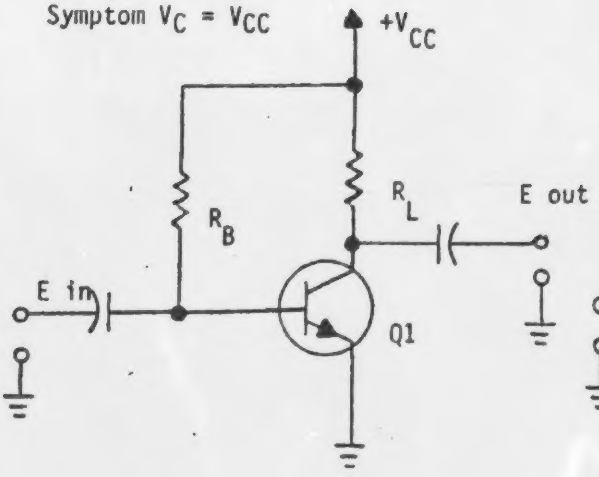

R_L
E out
E in
Q1
R_B
+ V_{CC}

Suspect: An open in the collector circuit or a shorted Q1, collector to emitter.

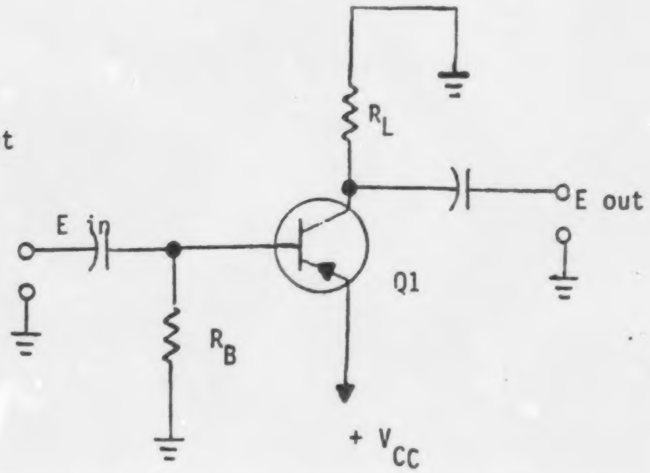
Confirm: Check Q1 and the collector circuit with an ohmeter.

Example #2

Symptom $V_C = V_{CC}$


$+V_{CC}$
R_B
R_L
E out
E in
Q1

Symptom $V_C = 0V$


R_L
E out
E in
Q1
R_B
+ V_{CC}

Suspect: An open transistor, (collector to emitter) or an open in the emitter circuit.

Confirm: Check Q1 and the emitter circuit with an ohmmeter.

FAULT ANALYSIS

(PAPER TROUBLESHOOTING)

FOR

MODULE 30, LESSON 2

NOW THAT YOU HAVE COMPLETED THE KNOWLEDGE SECTION OF THIS LESSON, YOU ARE READY FOR PAPER TROUBLESHOOTING.

THE COMPUTER WILL ASSIGN YOU A SET OF PAPER TROUBLESHOOTING PROBLEMS ON THE TRANSISTOR REGULATOR. THESE PROBLEMS WILL HELP YOU DEVELOP THE MENTAL SKILLS REQUIRED IN ACTUAL TROUBLESHOOTING. YOU WILL BE GIVEN SYMPTOMS OF A FAILURE AND CIRCUIT MEASUREMENTS THAT WILL ALLOW YOU TO IDENTIFY THE PROBLEM.

AFTER YOU COMPLETE THE PAPER TROUBLESHOOTING SECTION, THE COMPUTER WILL ASSIGN YOU A PRACTICE TROUBLESHOOTING PROBLEM ON A FAULTY PRINTED CIRCUIT BOARD.

REMEMBER THAT REFERENCE VOLTAGES, WAVEFORMS, AND A SCHEMATIC ARE CONTAINED IN THIS STUDENT GUIDE FOR YOUR USE IN BOTH PAPER AND ACTUAL TROUBLESHOOTING PROBLEMS.

TERMINAL OBJECTIVE:

30.2.49 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a complete regulating device when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

ENABLING OBJECTIVE:

30.2.49.13 IDENTIFY the faulty component, or the circuit malfunction, in a given voltage and current regulator, given a schematic diagram and failure symptoms, by selecting the correct fault from a choice of four. 100% accuracy is required.*

Footnote: * These objectives are considered met upon successful completion of the terminal objective.

OVERALL PERFORMANCE TEST INSTRUCTIONS

FOR

TROUBLESHOOTING PERFORMANCE TEST

INTRODUCTION:

Using the following six step troubleshooting procedure will aid you in determining which component is faulty. In the split method of troubleshooting, Pin #15 has been selected as the starting point for dividing the circuit in half. If the voltage at Pin #15 is higher than normal or nearly normal chances are your problem is in one of the stages following Pin #15. If the voltage at Pin #15 is lower than normal, this tells you that a circuit prior to Pin #15 is dropping all the voltage. Since you are not permitted to unsolder components in order to make resistance measurements, it may be necessary, in some cases to remove the PCB from the power supply in order to remove parallel paths.

EQUIPMENT:

1. NIDA 201 Power Supply
2. NIDA 201 Pre-faulted Circuit Board
3. Digital Multimeter
4. Simpson 260 Multimeter
5. 1 Pair of Multimeter Test Leads

INSTRUCTIONS:

1. Each student is required to determine the defective component in a prefaulted power supply PCB. You will be allowed 45 minutes of troubleshooting time on the equipment. Five additional minutes will be allowed (if required) to complete the failure analysis in step #6 at a penalty of 5 points.

2. Standard test equipment will be available to you in the form of a digital multimeter and a Simpson 260 multimeter. You will be expected to observe all safety precautions throughout the test. Improper use of test equipment will result in a 5 point penalty for each occurence. A safety violation will result in an automatic failure of the performance test. In that event you will be counselled and given remedial training.

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TROUBLESHOOTING PERFORMANCE TEST

3. You will take a numbered position in the test room. After briefing by the Learning Center Instructor you will fill out the heading of the troubleshooting form. On a signal from the Learning Center Instructor you will start the test. If at any time during the test you should require assistance, raise your hand. DO NOT LEAVE YOUR POSITION. A Learning Center Instructor will assist you with your trouble.

4. If you do not understand these instructions, raise your hand and ask your Learning Center Instructor. If you do understand these instructions and upon a signal from your Learning Center Instructor you may now begin the Performance Test on the next page.

SIX-STEP TROUBLESHOOTING PROCEDURES

FOR

TROUBLESHOOTING PERFORMANCE TEST

DIRECTIONS: DO NOT WRITE IN THE PERFORMANCE TEST BOOKLET. MAKE ALL YOUR RESPONSES ON THE 6 STEP TROUBLESHOOTING SHEET SUPPLIED WITH THIS TEST PACKET. THIS PERFORMANCE TEST BOOKLET IS DESIGNED TO AID YOU IN COMPLETING THE STANDARD 6 STEP TROUBLESHOOTING FORM. COMPLETE THE STEPS USING YOUR KNOWLEDGE AND SKILL OF THE CIRCUITS SHOWN. CONTACT YOUR LEARNING CENTER INSTRUCTOR IF YOU HAVE ANY QUESTIONS.

SET THE LOAD SELECTOR SWITCH ON THE NIDA 201L LOAD BOX TO FIXED LOAD. SET THE COARSE AND FINE VOLTAGE CONTROLS ON THE FRONT PANEL OF THE NIDA 201 POWER SUPPLY FULLY CW. SET THE CURRENT CONTROL ON THE NIDA 201 POWER SUPPLY TO MID-RANGE. IF THE POWER SUPPLY IS OPERATING PROPERLY AND THE NIDA 201 PRINTED CIRCUIT BOARD IS INSTALLED THE METERS SHOULD INDICATE 13 VDC, 0.9A APPROXIMATELY. ALL VOLTAGE AND RESISTANCE MEASUREMENTS WILL BE MADE WITH REFERENCE TO GROUND UNLESS THE PRINTED CIRCUIT BOARD IS REMOVED TO MEASURE FRONT TO BACK RESISTANCE RATIOS OR TO MEASURE THE RESISTANCE OF A SPECIFIC RESISTOR.

STEP ONE - SYMPTON RECOGNITION

1. Does the equipment energize? __________Yes/No

STEP TWO - SYMPTOM ELABORATION

1. What do the meters indicate
   - a. Normal
   - b. High
   - c. Low
   - d. Zero

STEP THREE - LIST THE PROBABLE FAULTY FUNCTION(S)

1. There are seven functions in this power supply
   - a. Shunt voltage regulator
   - b. Current limiter
   - c. Primary voltage regulator
   - d. Reference series voltage regulator
   - e. Voltage comparator
   - f. Current regulator
   - g. Output monitoring circuit

TROUBLESHOOTING PERFORMANCE TEST

STEP FOUR - LOCALIZE THE FAULTY FUNCTION

1. Verify the probable faulty function by use of test equipment.
2. List the test points where voltages were obtained.
3. Reference voltages are listed in the voltage chart.
4. Which function listed in step three above is the faulty function?

STEP FIVE - LOCALIZE THE FAULTY CIRCUIT/COMPONENT

1. List the test points where actual voltages were taken.
2. What circuit/component in the faulty function listed in step four is faulty?
3. If you have determined the faulty circuit but not the faulty component proceed to step six.

STEP SIX - FAILURE ANALYSIS

1. Secure the power and using the Simpson 260 take resistance checks.

   a. Check front to back ratios on diodes.
   b. Take continuity checks on printed circuit board foil.
   c. Capacitors can be shorted or open.
   d. Resistors can be open.
2. Explain in your own words why the component listed in steps five or six above would cause the symptoms listed in steps one and two of the six step troubleshooting procedure? Write your answer in the space provided below.

TAKE YOUR 6 STEP TROUBLESHOOTING SHEET TO YOUR LEARNING CENTER INSTRUCTOR FOR VERFICATION AND EVALUATION.

VOLTAGE/RESISTANCE CHART

The following Voltages and Resistances were taken with the load selector switch on the NIDA 201L load box set to fixed load. The fine and coarse voltage controls on the NIDA 201 power supply fully CW and the current control set to mid-range. All Voltage and Resistance measurements were made with reference to ground with the PC201 PCB installed in the NIDA 201 power supply.

POINT OF CHECK	VOLTAGE	RESISTANCE
Pin #7	40.2 VDC	1500 Ohms
Pin #9	36.1 VDC	2200 Ohms
Pin #10	37.9 VDC	1950 Ohms
Pin #12	38.5 VDC	1500 Ohms
Pin #14	37.7 VDC	2200 Ohms
Pin #15	16.3 VDC	3200 Ohms
Pin #16	16.3 VDC	550 Ohms
Pin #18	15.6 VDC	17.5 Ohms
Pin #19	8.3 VDC	2250 Ohms
Pin #20	7.5 VDC	1100 Ohms
Pin #21	12.46 VDC	775 Ohms
Pin #22	7.49 VDC	1100 Ohms
Pin #23	12.48 VDC	800 Ohms
V_E Q5	37.1 VDC	5575 Ohms
V_B Q4	17.1 VDC	2000 Ohms
V_B Q7	13.2 VDC	2000 Ohms
V_C Q7	12.5 VDC	2100 Ohms
V_E Q8 and V_E Q9	11.64 VDC	200 Ohms
V_C Q8	11.68 VDC	200 Ohms
V_B Q6	34.6 VDC	4500 Ohms
V_E Q6	35.1 VDC	2200 Ohms

SCHEMATIC DIAGRAM

NIDA MODEL 201

POWER SUPPLY TRAINER

PC 201

P.P. 76-77

SUMMARY
LESSON 3

SCR Power Supply Circuits

A power supply which provides a maximum amount of power output is required for some transmitters, receivers, computers, radar systems and other electronic equipments. The power supply which provides this high current output with a minimum internal power loss is the silcon controlled rectifier (SCR) type power supply.

The symbols for a regular diode and an SCR are shown in Figure 1. These symbols are provided to help you understand the difference between the two components.

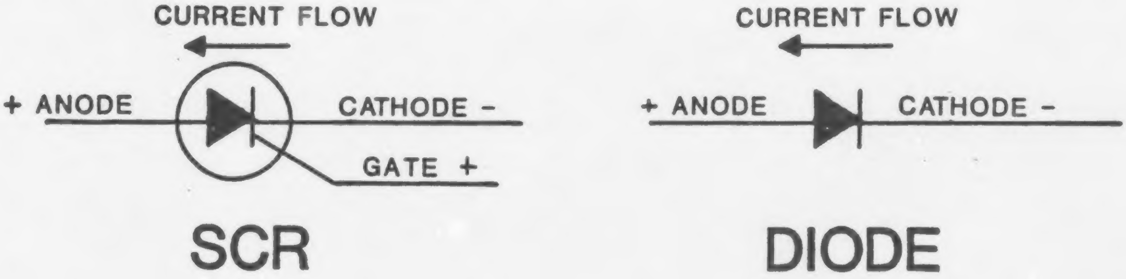

Figure 1

SCHEMATIC SYMBOLS

Both the diode and SCR have a cathode and an anode. However, the SCR has an additional element which is called the gate. The gate provides the triggering or turn-on capability for the SCR.

You already know that neither the diode nor the SCR conduct when they are reversed biased, and therefore block current flow through other components which are connected in series with them.

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The difference between the diode and the SCR is that even when the SCR is forward biased, it will not conduct until an adequate positive voltage is applied to its gate. Of course once conducting, it behaves like a diode and continues to conduct until the forward bias is removed or a reverse bias is applied. This gate voltage may be momentary, since a continuous gate voltage is not required to assure continued current flow. If you have difficulty understanding the concept of SCR gating please refer back to Module 25 or study an alternate form of this lesson.

Since the gate has turn-on capability only when the SCR is forward biased, once the SCR is conducting the gate no longer has control over the SCR regardless of the gate potential. The SCR is turned off only when it it is reverse biased or the forward bias has been removed.

The schematics shown in Figure 2 are for a half-wave diode power supply and a half-wave SCR power supply.

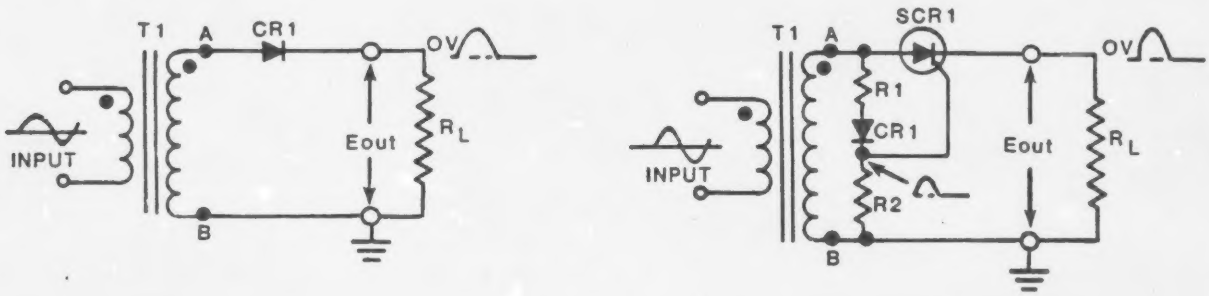

Figure 2

HALF-WAVE SCR
POWER SUPPLY
(UNFILTERED)

HALF-WAVE DIODE
POWER SUPPLY
(UNFILTERED)

The SCR power supply is similar to the ordinary diode power supply which you have studied previously. The only difference is that SCRs are used instead of diodes and the SCRs have the capability of controlling the conduction time and the amount of current which ultimately reaches the filter and load. Study the schematics and notice that even though they are essentially identical, several additional components have been added to the SCR power supply. These components, consisting of R1, R2, and CR1, are used to trigger or turn on the SCRs.

The waveforms shown in Figure 3 show pictorially how the SCR operates with an AC input.

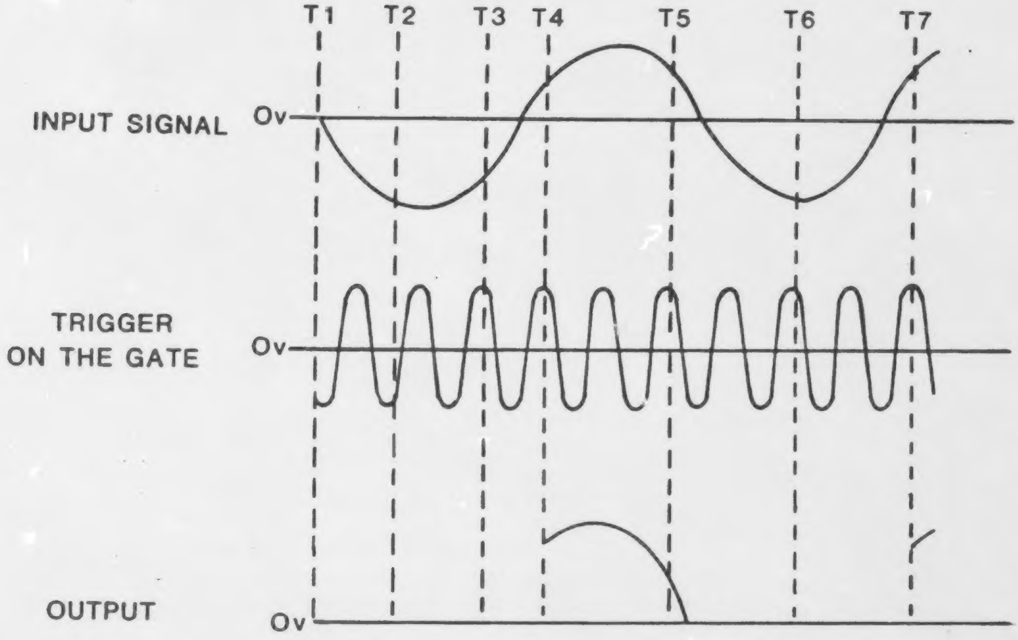

Figure 3

SCR TIMING WAVEFORMS

Notice that as long as the input signal is negative, current cannot flow and consequently there is no output. Even when the input signal becomes positive and the SCR is forward biased, the SCR will not conduct until a positive trigger voltage is applied to the SCR gate. This voltage must equal or exceed the gate or trigger voltage rating of the SCR. SCRs with different trigger voltage ratings are available. Make sure you understand the waveforms shown and the time the SCR conducts and when it stops conducting, before proceeding further with this lesson.

Although half-wave SCR power supplies are seldom used, an understanding of their operation will help you understand how the full-wave SCR power supply operates.

Figure 4 shows the schematic for a half-wave SCR power supply.

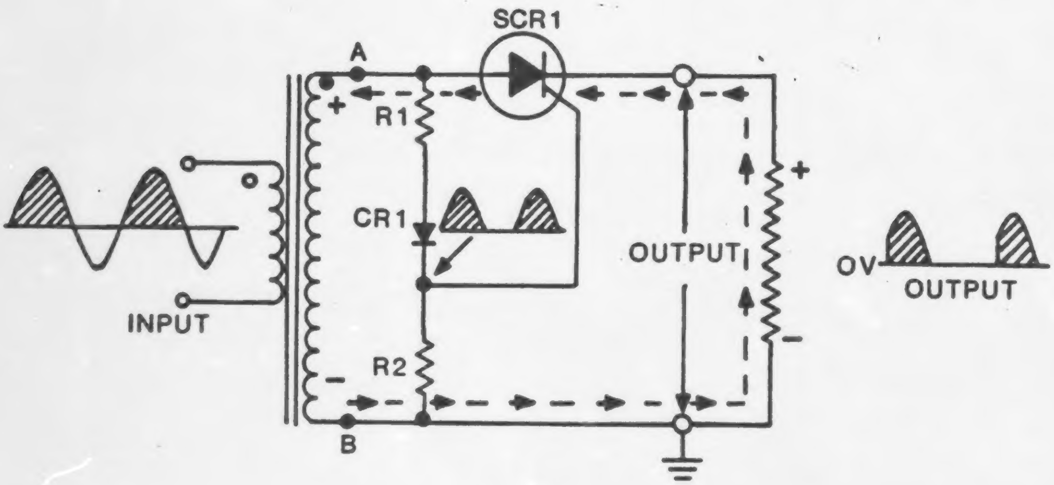

Figure 4

UNFILTERED SCR HALF-WAVE POWER SUPPLY

R1, R2 and CR1 make up a half-wave gating network for the SCR power supply. SCR1 and RL are the half-wave SCR components.

Recall that an SCR will not conduct unless it is forward biased and a positive potential is applied to its gate. Therefore current flows through R1 and R2 only when terminal A of T1 is positive. At this time CR1 is forward biased. When terminal A becomes negative CR1 is reverse biased and current does not flow. Voltage is developed across R2 only during the positive half cycle and the gate triggers the SCR at this time. This means that SCR current can only flow during the positive cycle.

The waveforms shown immediately to the right of the schematic indicate the output of the power supply during positive alternations. Trace the current flow and make sure you understand how this half-wave SCR supply rectifier operates before proceeding further.

Since the gate voltage is dependent on the voltage divider, the firing time of the SCR may be changed by changing the value of the voltage divider resistors. For example, if the resistance of R2 is increased, the gate vcltage trigger level on the SCR will be reached sooner, resulting in an earlier SCR turn on. This causes the SCR to conduct for a longer period of time before the positive alternation ends and the SCR again becomes reverse biased. Thus, the output voltage is variable by making R2 a variable resistor.

Waveforms shown in Figure 5 illustrate the effect of different resistance values of R2 and the corresponding output of the SCR. Note particulary that a large value of R2 results in an earlier firing time and that the gate potential and the output is only present during the positive input cycle. This is shown by the two waveforms immediately below the input waveform. Study the other waveforms to make sure you understand what happens when R2 has a small value, and a filter is added to the output.

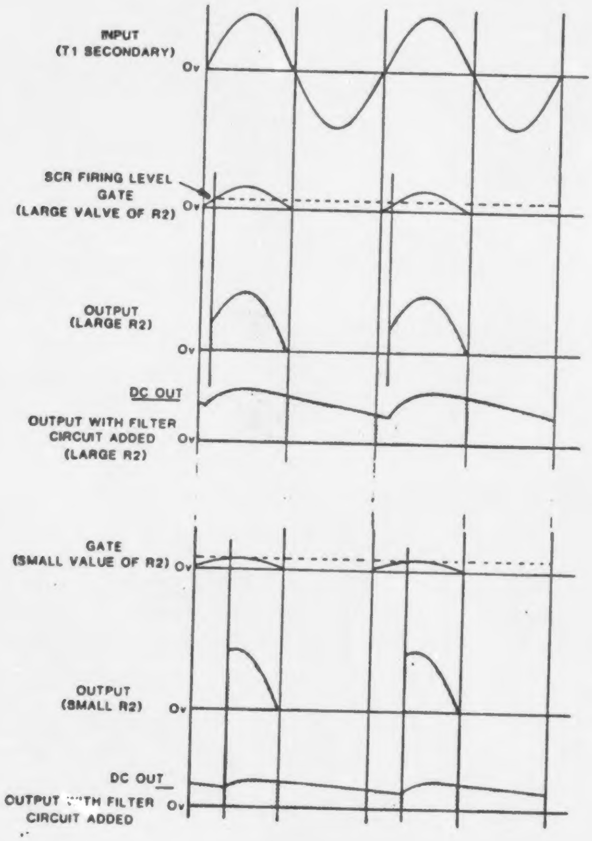
INPUT
(T1 SECONDARY)
Ov
SCR FIRING LEVEL
GATE
(LARGE VALVE OF R2)
Ov
OUTPUT
(LARGE R2)
Ov
DC OUT
OUTPUT WITH FILTER
CIRCUIT ADDED
(LARGE R2)
Ov
GATE
(SMALL VALUE OF R2)
Ov
OUTPUT
(SMALL R2)
Ov
DC OUT
OUTPUT WITH FILTER
CIRCUIT ADDED
Ov

Figure 5

HALF-WAVE SCR WAVEFORMS

Thus far the explanation has been concerned with one-half of a full-wave SCR rectifier. The schematic shown in Figure 6 represents a full-wave SCR rectifier. Recall that the advantage of full-wave rectification is an output which has twice as many pulses and is therefore easier to filter. The gating networks for the SCRs are shown in shaded blocks.

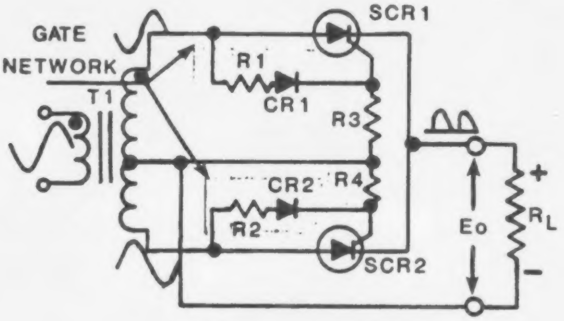

Figure 6

FULL-WAVE SCR POWER SUPPLY

Waveforms shown in Figure 7 illustrate the output of the full-wave SCR rectifier during two complete input cycles. Study the waveforms and schematic shown in Figures 6 and 7 in order to make sure that you understand how the full-wave SCR power supply operates.

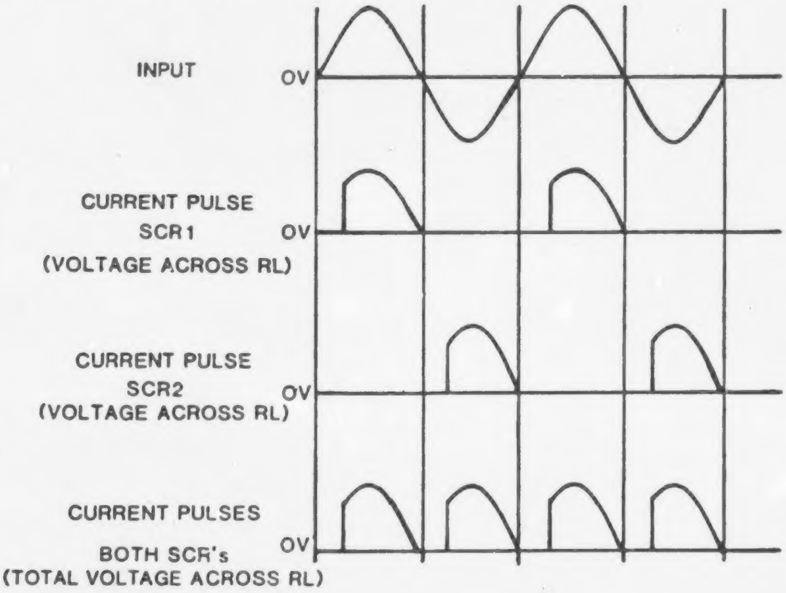

Figure 7

FULL-WAVE SCR RECTIFIER WAVEFORMS

Full-wave SCR power supplies, like full-wave diode power supplies, require a center tapped transformer secondary, and therefore, only half of the transformers secondary potential is utilized at any given time. In order to make full use of the secondary voltage an SCR bridge power supply may be used.

In many respects the SCR bridge power supply is identical to a regular bridge diode power supply. The schematics shown in Figure 8 should acquaint you with the similarities of the two types of power supplies.

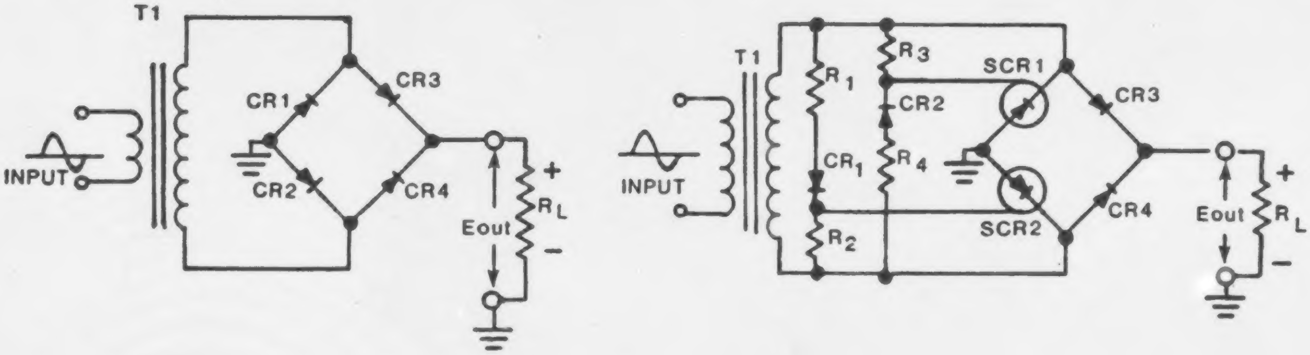

Figure 8

STANDARD DIODE BRIDGE SCR BRIDGE POWER SUPPLY

Notice particularly that the only difference between the two schematics is that the SCR bridge power supply uses two SCRs and gating or triggering networks. Also notice that the SCRs are connected so that one of the SCRs is always in series with load. Stated in simpler terms, one of the SCRs always controls the load current. It may be advantageous if you trace around the circuit and familiarize yourself with the concept that SCR1 is in series with CR4 and SCR2 is in series with CR3.

When terminal A of T1 is positive, CR1, CR3 and SCR2 are forward biased. This also causes current to flow from terminal B of T1, through R2, CR1, R1 and back to terminal A. No additional current flows at this time due to the fact that SCR2 has not been gated or triggered. When the voltage drop across R2 reaches the firing potential for SCR2, the SCR conducts and current flows from terminal B through SCR2 to ground. The current path to terminal A is thereby completed from ground on the bottom of RL through CR3. This current path exists until the polarity of the voltage across the secondary reverses. When terminal A is negative with respect to terminal B, the action is similar. This secondary voltage polarity will forward bias SCR1, CR4 and CR2. Trace the current paths for this alternation to be sure you understand the SCR bridge power supply.

The addition of filter components to any of the SCR power supply circuits will provide a smooth DC output voltage, instead of the pulsating voltage shown on many of the output waveforms. Circuit operation remains the same.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, YOU MAY TAKE THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAME SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 3

SCR Power Supplies

TERMINAL OBJECTIVE(S):

30.3.50 When the student completes this lesson (s)he will be able to IDENTIFY the schematic diagrams, component functions, and operational principles of SCR power supply circuits, including the relationship between the conduction time of an SCR and the DC output voltage. 100% accuracy is required.

ENABLING OBJECTIVES

When the student completes this lesson, (s)he will be able to:

30.3.50.1 IDENTIFY the operating characteristics of a silicon controlled rectifier (SCR), including the conditions controlling the start, duration , and stop time of SCR conduction, by selecting the correct statement from a choice of four. 100% accuracy is required.

30.3.50.2 IDENTIFY the advantages of SCR power supplies by selecting the correct set of their characteristics from a choice of four. 100% accuracy is required.

30.3.50.3 IDENTIFY the schematic diagrams of full-wave, half-wave and bridge type SCR power supplies by selecting the correct name or diagram from a choice of four. 100% accuracy is required.

30.3.50.4 IDENTIFY the function of components and circuit operation (including their control of SCR conduction time) in full-wave, half-wave, and bridge-type SCR power supplies by selecting the correct statement from a choice of four. 100% accuracy is required.

30.3.50.5 IDENTIFY the relationship between SCR conduction time and the amount of DC output voltage in full-wave, half-wave and bridge type SCR power supplies by selecting the correct explanation from a choice of four. 100% accuracy is required.

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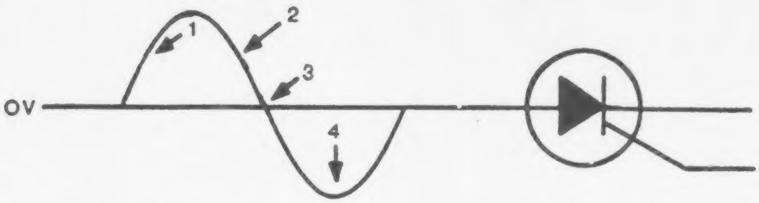
PROGRESS CHECK
LESSON 3

SCR Power Supplies

1. A primary advantage of the SCR bridge power supply is it

   a. uses a center tapped transformer
   b. has low internal power losses
   c. uses a large load resistor
   d. may be connected to produce either a positive or negative output

STUDY THE WAVEFORM SHOWN BELOW IN ORDER TO ANSWER QUESTION 2



2. Assume the SCR is conducting. At what point in the input signal waveform does the SCR turn off?

   a. 1
   b. 2
   c. 3
   d. 4

3. A forward biased SCR will conduct whenever an adequate

   a. negative voltage is applied to the gate
   b. negative voltage is applied to the cathode
   c. positive voltage is applied to the gate
   d. positive voltage is applied to the cathode

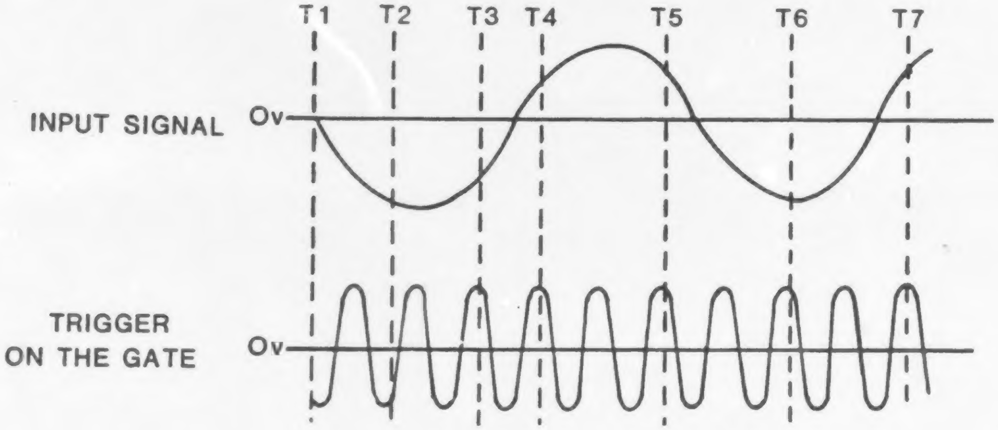
4. A forward biased SCR continues to conduct until

   a. the gate signal is removed
   b. a negative voltage is applied to the gate
   c. the forward bias is removed or a reverse bias is applied
   d. the gate voltage exceeds the SCRs forward bias

5. The gate of a silicon controlled rectifier has control only when the SCR is

   a. reversed biased and the gate voltage is positive.
   b. forward biased and the gate voltage is negative.
   c. reverse biased and the gate voltage is both negative and greater than the bias of the SCR.
   d. forward biased and the gate voltage is positive.

STUDY THE WAVEFORMS SHOWN BELOW IN ORDER TO ANSWER QUESTIONS 6 AND 7



6. The SCR conducts at time(s)

   a. T1
   b. T4 and T7
   c. T6
   d. T2 and T3

7. Once the SCR has been triggered it continues to conduct until time frame

   a. T3
   b. T4
   c. T5
   d. T6

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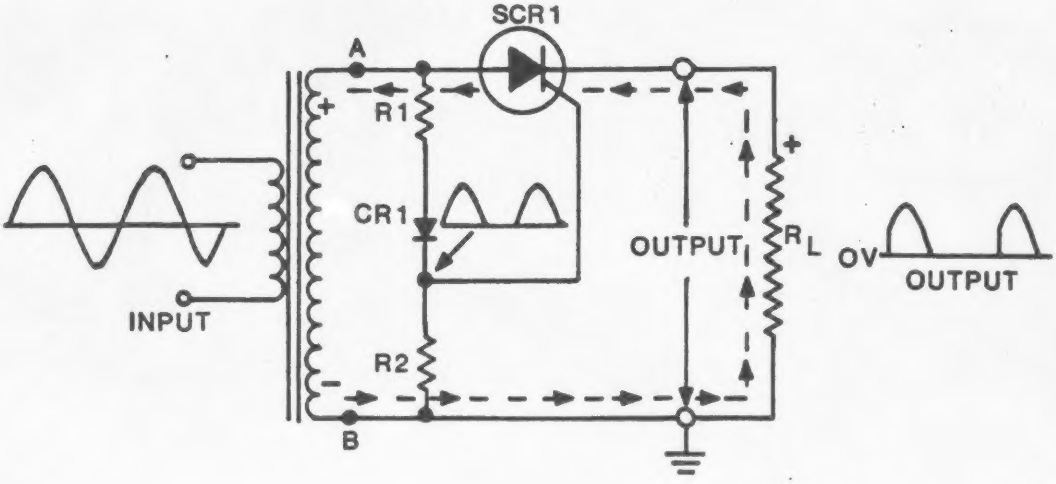
REFER TO THE FIGURE SHOWN BELOW IN ORDER TO ANSWER QUESTIONS 8 AND 9



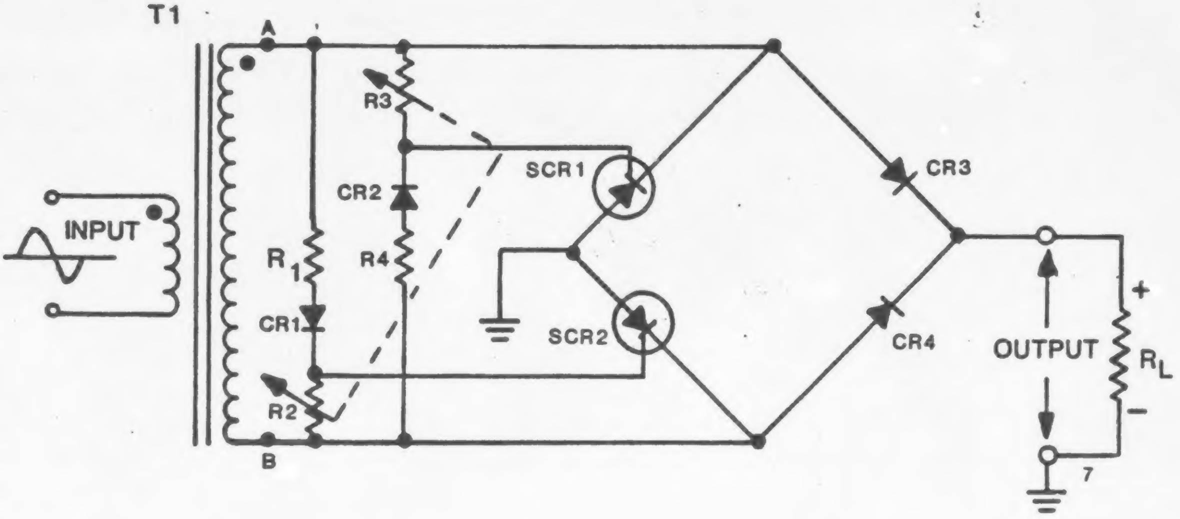
8. When the value of R2 is increased, the SCR will trigger

   a. later
   b. sooner
   c. when reversed biased
   d. can't tell based on information given

9. When the resistance of R2 is decreased, the average output of this half-wave power supply

   a. increases
   b. decreases
   c. remains the same
   d. cannot be determined based on the information given

REFER TO THE SCHEMATIC BELOW WHEN ANSWERING QUESTIONS 10 AND 11


T1
A
B
INPUT
R3
CR2
R4
R1
CR1
R2
SCR1
SCR2
CR3
CR4
OUTPUT
+
−
RL
7

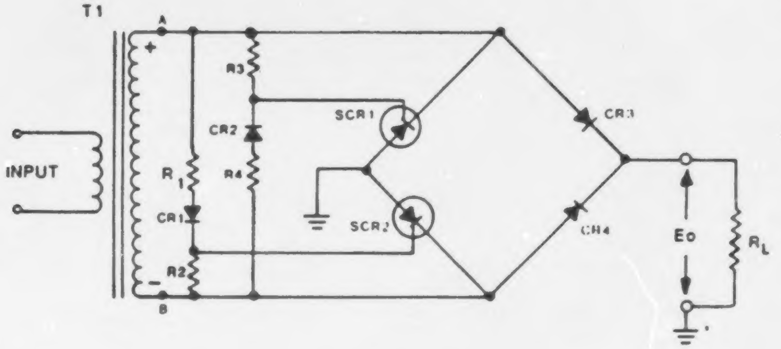
10. Decreasing the value of R2 and R3 results in _______ in the average DC voltage across RL.

    a. a decrease
    b. an increase
    c. no change
    d. none of the above

11. The amount of output voltage is determined by

    a. the conduction time of the SCRs
    b. the input voltage
    c. the different values of R2 and R3
    d. all of the above

REFER TO THE SCHEMATIC SHOWN IN THE FIGURE BELOW IN ORDER TO ANSWER QUESTION 12



12. In the SCR bridge power supply shown, the SCR(s) that will be "gated on" with the polarities shown is/are:

    a. SCR 1
    b. SCR 2
    c. both SCR 1 and 2
    d. none of the above

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY AND FEEL READY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

Time waits for no man. . .

ACCIDENTS WAIT FOR EVERYONE

COMPLACENCY KILLS!

[illegible]

C32-GS-567

Contributed by AMHC K M Carpenter, VP-4

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SUMMARY
LESSON 4

SCR Regulated Power Supplies

In lesson three of this module you learned about SCR Power Supply Circuits and the advantages which these circuits provide over conventional diode power supplies. This lesson covers circuits which have been designed to control the output of SCR Power Supplies.

By using control circuitry, the amount of time the power supply SCRs conduct can be regulated. Recall that the conduction time of the SCR determines the output voltage of the power supply. The control circuit also compensates for variations in input voltage and circuit load. The diagram shown in Figure 1 indicates pictorially how the conduction time of the SCR is controlled and shows the effect of varying SCR trigger times.

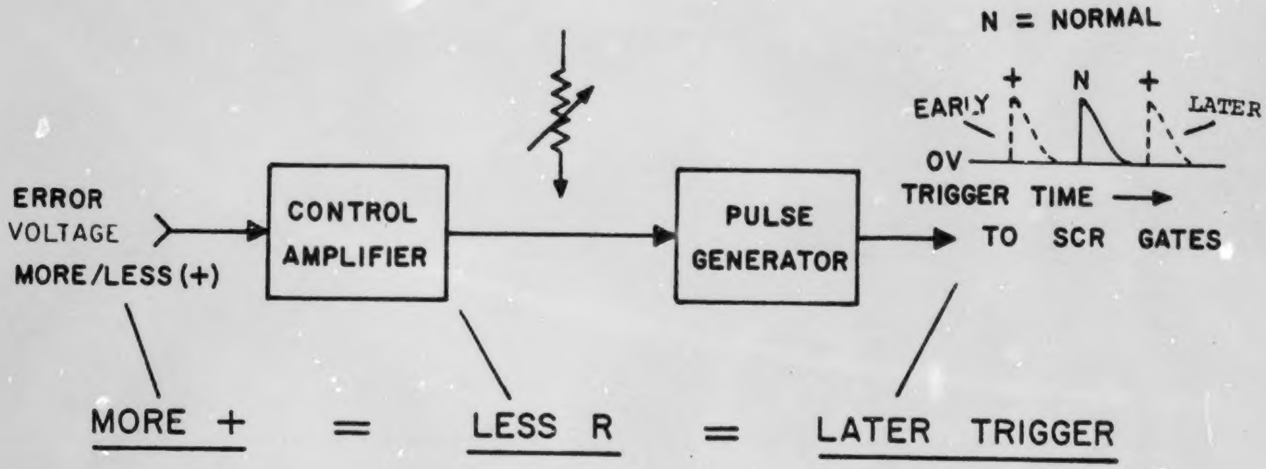

N = NORMAL
+
N
+
EARLY
LATER
OV
TRIGGER TIME →
ERROR VOLTAGE MORE/LESS (+)
CONTROL AMPLIFIER
PULSE GENERATOR
TO SCR GATES
MORE + = LESS R = LATER TRIGGER

Figure 1

CONTROL CIRCUITS

Two stages are required in order to control conduction time. Stage 1 is referred to as the control amplifier and stage 2 may be referred to as the pulse generator. The output from the pulse generator is supplied to the SCR gates and determines when the SCR's will trigger or fire.

The waveforms shown in the upper right hand corner of the figure illustrate different turn-on times for the SCRs. The waveform at the extreme left **(+)** indicates an early turn-on time, whereas the waveform on the right (+) shows a delayed turn-on, or gating. The waveform designated with the "N" illustrates the usual, or "normal" turn on time. The **(+)** and (+) signs denote the error voltage level that produces the particular early or late trigger. A less positive error voltage is denoted by (+), while a more positive error voltage is denoted as **(+)**.

The pulse generator triggers, or gates, the SCRs on early, whenever there is an increase in load current or decrease in input voltage. It triggers the SCRs later to compensate for a decrease in load current or increase in input voltage. Make sure you understand this concept before proceeding further with this lesson. The schematic in Figure 2 shows the control circuit required for a typical SCR regulated power supply.

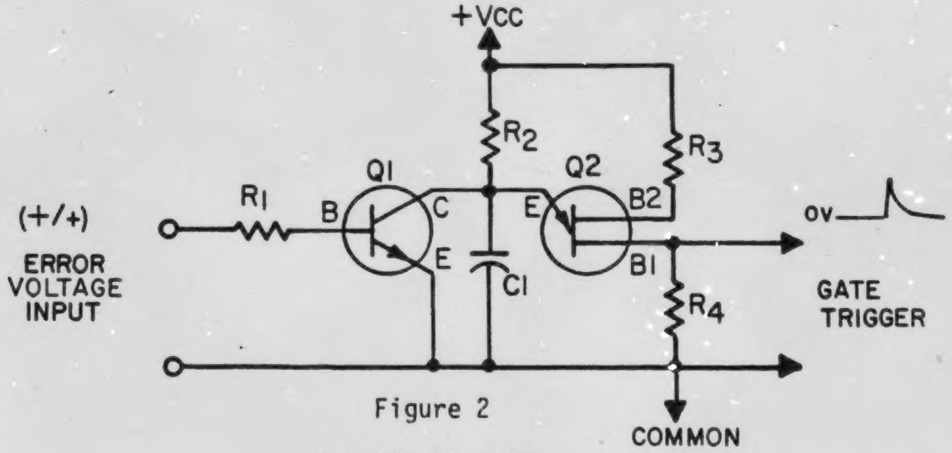


Figure 2

CONTROL CIRCUIT

The control amplifier is made up of Q1, current limiting resistor R1, and collector load resistor R2. The pulse generator trigger frequency is determined by the charging time of C1. R2 and the variable resistance of Q1, together with C1 determine C1's charging time.

The size of the error voltage determines the forward bias of Q1 and this results in either an increase or decrease in the transistor's internal resistance. This change in Q1's resistance influences the time it takes C1 to charge. This is a basic concept essential to understanding the operation of the control circuit.

Again refer to the schematic shown in Figure 2 and the components which make up the pulse generator circuit. This circuit is made up of unijunction transistor Q2, C1, R2, R3, and R4. If you do not recall how UJT's oscillate to produce trigger output pulses, refer to Lesson 2 of Module 25.

The schematic shown in Figure 3 is for the pulse generator circuit.

Before the UJT can trigger or fire the SCR, the UJT's emitter-base 1 forward bias must be adequate to trigger or fire the UJT. The UJT emitter-base 1 forward bias is dependent on the charging time of C1. When the capacitor charges quicker, the UJT fires sooner and the conduction time of the SCRs increase, thus increasing the output voltage. Delayed charging of C1 causes the UJT to fire later with a corresponding decrease in conduction time and output voltage.

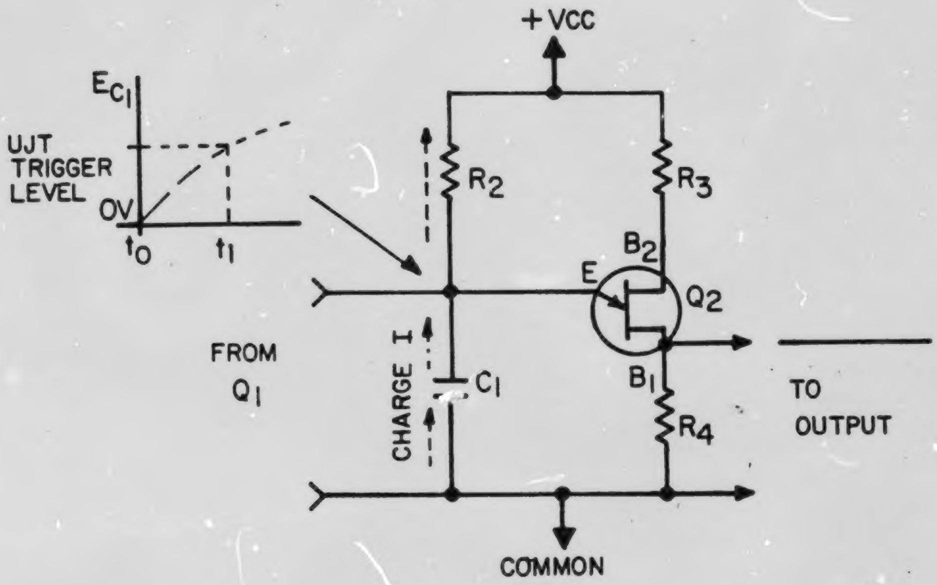


Figure 3

PULSE GENERATOR CIRCUIT

In addition to the basic circuit, C1's charging action is shown in the upper left hand corner of the figure.

During time cycle T0 through T1, C1 charges toward the UJT trigger level potential through R2. Because the UJT has not yet triggered the SCR, there is no output at this time. When the voltage across C1 reaches the trigger level of the UJT, the UJT fires. In other words, when the emitter-base 1 junction of the UJT becomes forward biased, the UJT conducts. This allows C1 to discharge rapidly through R4. The discharge current through R4 produces the output pulse.

After the capacitor discharges the emitter-base 1 junction of the UJT again becomes reverse biased and current no longer flows. C1 now charges again and the cycle repeats. You should now understand the effect of charging and discharging C1 on the pulse generator circuit.

Q1 is the variable component which influences the charging rate of C1. It operates somewhat like a variable resistor to modify C1's charging times. The schematic shown in Figure 4 depicts the transistor as a variable resistor R_{Q1}. Recall that the resistance of a transistor changes depending on its base-emitter forward bias. If you are unable to recall this relationship refer to Lesson 2 of this module or Module 21.

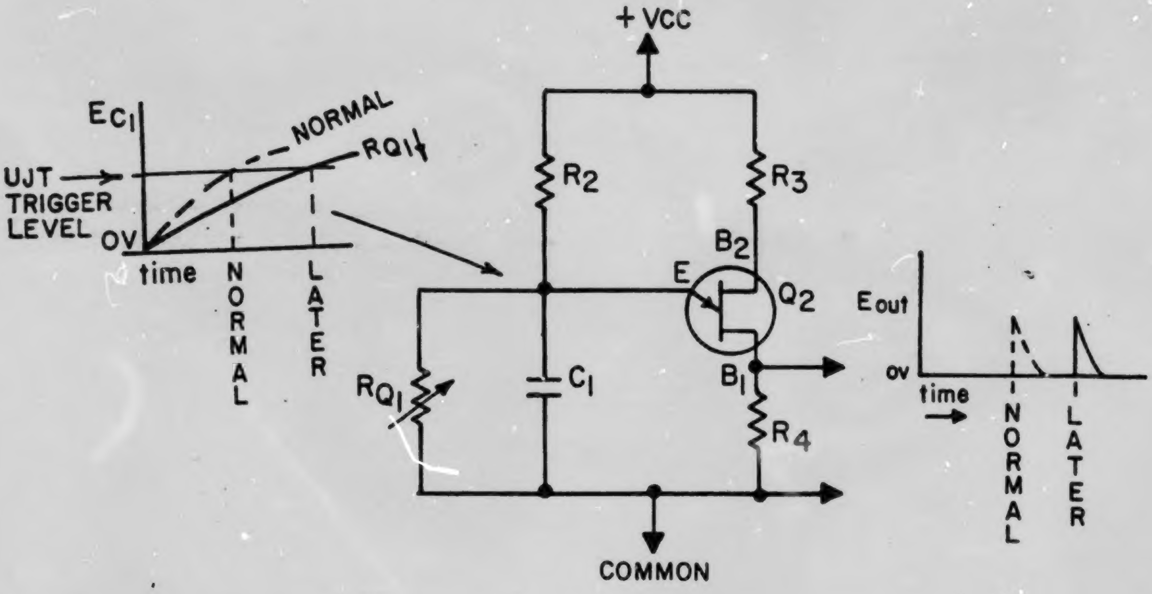


Figure 4

PULSE GENERATOR CIRCUIT

The waveforms shown on the right side of the figure indicate the pulse or trigger time of the UJT for normal operation and trigger time when the input voltage of the power supply is increased. The waveforms on the left side of the schematic indicate when C1 forward biases Q2 and causes the UJT to trigger or pulse the SCR.

Any increase in the input voltage increases the forward bias of Q1, thereby decreasing its resistance. This causes C1 to reach maximum charge later and causes the UJT to trigger the SCRs later. Study the schematic and waveforms and make sure you understand how changes in circuit load current effect the triggering or firing time of the UJT.

Up to this point the explanation has concentrated on the control and triggering circuits of the regulating device. A schematic for a typical SCR power supply together with control circuitry is shown on the foldout appended to the end of this lesson. This diagram is the schematic for the NIDA SCR regulated power supply which you will use as part of the job program for this lesson. Refer to this schematic for the remainder of the lesson. Notice that the rectifier and filter circuit is designated with heavy lines and the control circuitry is shown with light lines. Notice that two bridge rectifiers are shown. The main bridge rectifier consists of SCRs Q3 and Q4 and diodes CR5 and CR6. The other bridge circuit is made up of CR3, CR4, CR5 and CR6. This voltage is regulated by the Zener diode CR1 and R1. The output of this bridge circuit is used to provide a positive regulated voltage to Q1 and Q2 in the control circuit, and thus improve the total circuit regulating action.

As you study the schematic notice that CR5 and CR6 are used in both of the bridge circuits. Since these diodes are used in both circuits they conduct more current than CR3 and CR4.

The waveforms shown in Figure 5 are included to help you understand the operation of the power supply.

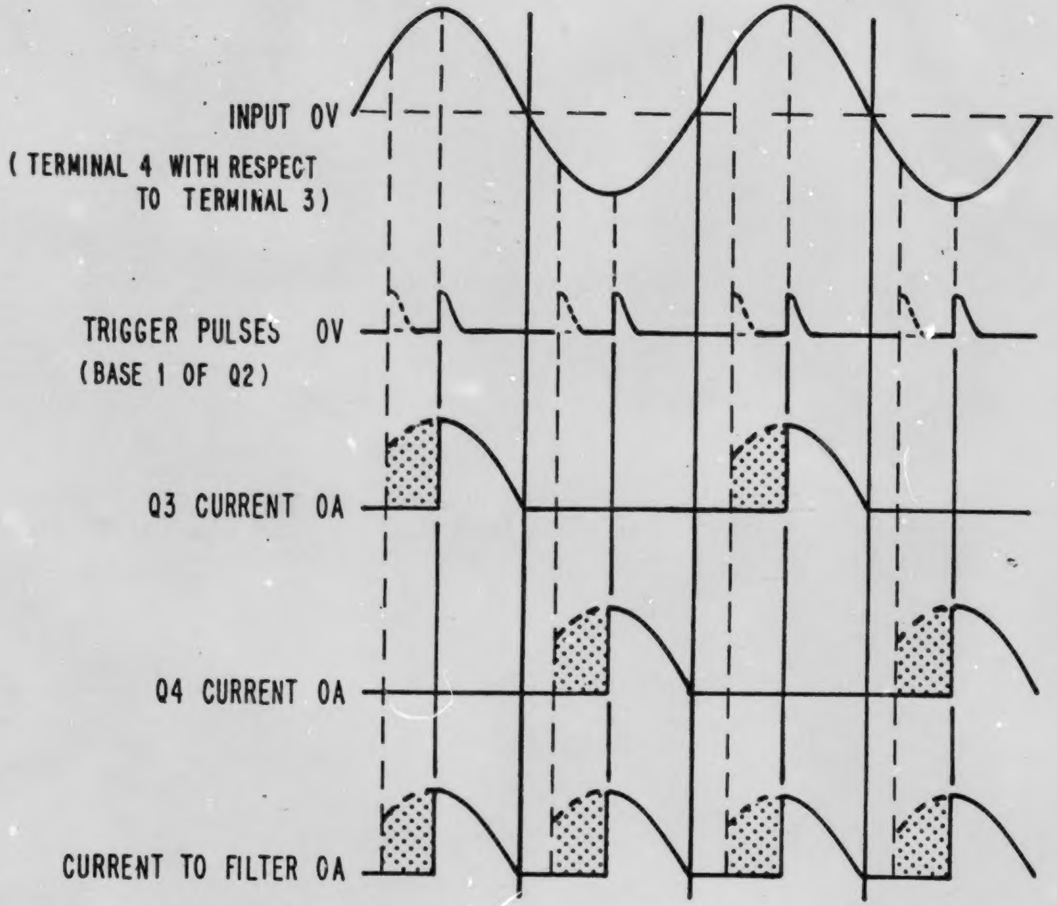


Figure 5

NORMAL OPERATING WAVEFORMS

The solid waveforms show a normal input and output for the power supply. The broken lines illustrate how the triggering time and output change when the load current is increased or the input voltage decreases.

The waveforms shown in Figure 6 show what happens when the input voltage increases or the load current decreases.

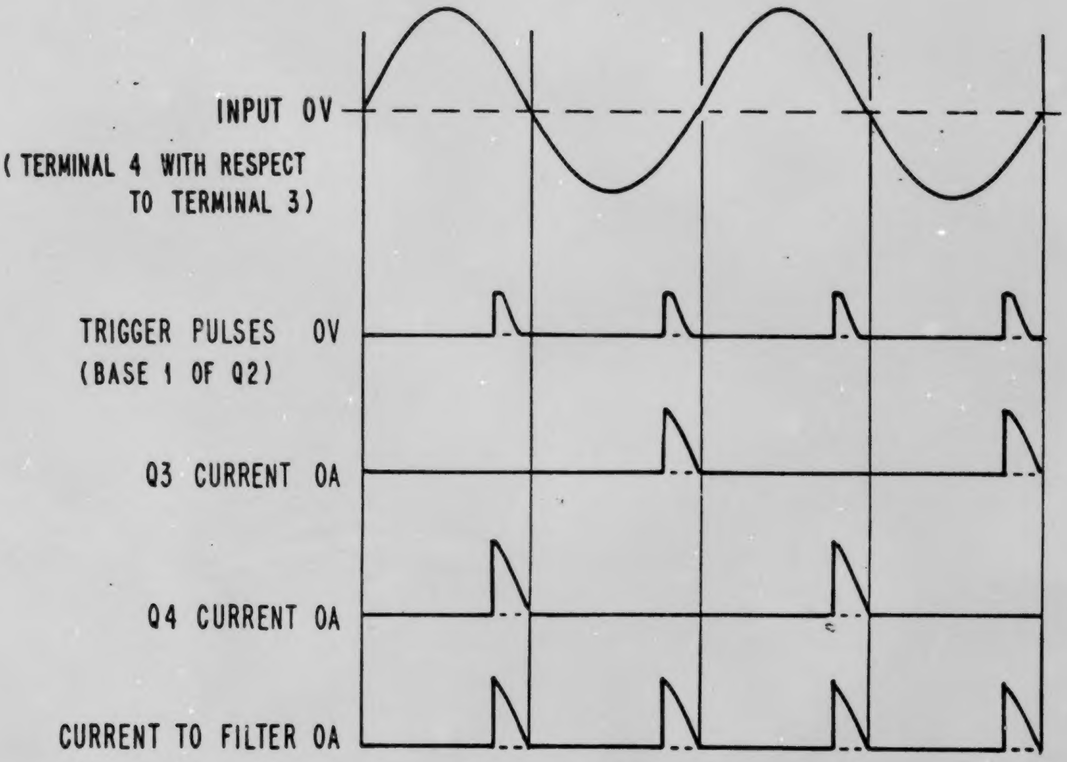


Figure 6

WAVEFORMS FOR INCREASED VOLTAGE OR REDUCED LOAD

Study these waveforms and those shown in Figure 5 in conjunction with the NIDA SCR schematic and try to visualize how the various components compensate for changes in load and/or input. This should give you a good understanding of how SCR regulated power supplies operate.

If you have difficulty understanding the material in this summary read and study either the narrative or programmed instruction for this lesson. This summary only covers the major concepts of circuit operation.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 4

SCR Regulated Power Supplies

The learning objectives of this lesson are:

TERMINAL OBJECTIVE(S):

30.4.51 When the student complete this lesson (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a regulated SCR power supply circuit when given a prefaulted circuit board, schematic diagram, instructions and necessary test equipment. 100% accuracy is required.

ENABLING OBJECTIVES:

When the student completes this lesson, (s)he will be able to:

30.4.51.1 IDENTIFY the function and basic principles of operation of the control circuit in an SCR regulated power supply, by selecting the correct statement from a choice of four. 100% accuracy is required.

30.4.51.2 IDENTIFY the function and operating characteristics of the control amplifier and pulse generator stages of an SCR regulated power supply control circuit by selecting the correct statement from a choice of four. 100% accuracy is required.

30.4.51.3 IDENTIFY the components that make up each of the two stages of an SCR regulated power supply control circuit, given a schematic diagram of the circuit, by selecting the correct list of components from a choice of four. 100% accuracy is required.

30.4.51.4 IDENTIFY the function of components and circuit operation of a two-stage SCR regulated power supply control circuit by selecting the correct statement from a choice of four. 100% accuracy is required.

30.4.51.5 IDENTIFY the components which make up the individual circuits within a complete SCR regulated power supply, given a schematic diagram, by selecting the correct list of components from a choice of four 100% accuracy is required.

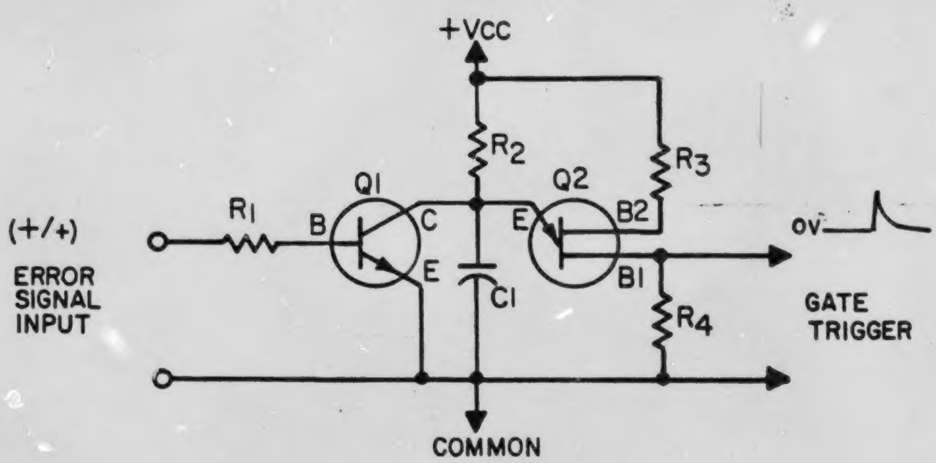
PROGRESS CHECK
LESSON 4

SCR Regulated Power Supplies

1. The output voltage of an SCR regulated power supply may be increased by

   a. applying a negative voltage to the SCR gates
   b. increasing the load current
   c. increasing the conduction time of the SCRs
   d. delaying the pulse time of the UJT

REFER TO THE SCHEMATIC BELOW WHEN ANSWERING QUESTIONS 2, 3 and 4.


+VCC
R2
R3
Q1
Q2
R1
B
C
E
E
B2
B1
(+/+)
ERROR
SIGNAL
INPUT
C1
R4
OV
GATE
TRIGGER
COMMON

2. The variable component which effects the time it takes capacitor C1 to charge is

   a. R1
   b. Q2
   c. Q1
   d. R2

3. A more positive error voltage causes capacitor C1 to charge faster/slower __________ and the UJT to fire the SCRs sooner/later __________.

   a. faster, sooner
   b. slower, later
   c. faster, later
   d. slower, sooner

4. After C1 discharges, the emitter-base 1 junction of the UJT becomes forward/reverse __________ biased and begins/stops __________ conducting.

   a. reverse, begins
   b. forward, begins
   c. reverse, stops
   d. forward, stops

REFER TO THE FOLDOUT SCHEMATIC FOR THE NIDA SCR POWER SUPPLY WHEN ANSWERING QUESTIONS 5 THROUGH 10.

5. Moving the wiper arm of R17 in a CCW direction

   a. increases the power supply output
   b. decreases the power supply output
   c. increases the voltage across R9
   d. decreases the forward bias of Q1

6. The conduction time of Q3 and Q4 depends on the time of the pulse, or triggering, action of

   a. Q1
   b. Q2
   c. CR1
   d. CR2

7. An increase in the voltage drop across R5

   a. has no effect on the charging time of C1
   b. increases C1's charging time
   c. decreases C1's charging time
   d. causes the UJT to fire quicker

8. C3 is used to

   a. filter out RF from the power supply
   b. provide a constant load resistance for the power supply
   c. filter the power supply output
   d. none of the above

9. A momentary decrease in the voltage at TP3 will

   a. have no effect on the UJT triggering time
   b. cause the UJT to trigger later
   c. cause the UJT to trigger sooner
   d. cause an overload in the control circuit

10. The UJT triggers SCRs Q3 and Q4 later to compensate for a/an

    a. increase in load current and an increase in input voltage
    b. decrease in load current and a decrease in input voltage
    c. increase in load current and a decrease in input voltage
    d. decrease in load current and an increase in input voltage

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWERED ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULATION WITH LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

JOB PROGRAM
FOR
LESSON 4

SCR Regulated Power Supplies

INTRODUCTION

This Job Program will demonstrate SCR Regulated Power Supplies and their operation. It is designed to permit you to prove to yourself the principles you studied on SCR Regulated Power Supplies. Since the input voltage cannot be varied because this voltage is applied to the equipment from a receptacle, the Job Program will be oriented toward changes in load and output voltage.

TERMNAL OBJECTIVE(S):

30.4.51 When the student completes this lesson (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a regulated SCR power supply circuit when given a prefaulted circuit board, schematic diagram, instructions, and necessary test equipment. 100% accuracy is required.

ENABLING OBJECTIVE(S):

When the student completes this lesson, (s)he will be able to

30.4. 51.7 MEASURE, CALCULATE and COMPARE output voltages, waveforms, and SCR conduction times in an SCR regulated power supply given a training device, circuit boards, test equipment, and proper tools, schematic diagram, and a job program containing references for comparison. Recorded data must be within limits stated on the job program.

SAFETY PRECAUTIONS

Observe all standard safety precautions. Beware of all open and bare connections; an energized circuit may have dangerous voltages present. When using the oscilloscope probes to view and measure waveforms, take care not to short the tip of the probes to other connections. Do not permit the front panel ammeter to exceed 1 ampere since the protective fuse is rated at 1 ampere.

EQUIPMENT AND MATERIALS

Note: Refer to NIDA 201-6 Schematic Diagram (Foldout) Pg. 321

1. NIDA 201 Power Supply
2. NIDA 201-6 Printed Circuit Board
3. NIDA 201L Load Box
4. Oscilloscope
5. 10X Probes (2)
6. Double Banana Plug Cable
7. NIDA 201-6 Schematic Diagram

PROCEDURES

1. Energize and set up the oscilloscope for dual trace operation. (Allow sufficient time for the oscilloscope to warm up).

2. Connect the 10X probes to the two vertical channels on the oscilloscope. Select the "line" position of the trigger source switch.

3. Connect the NIDA 201L load box to the power supply using the double banana plug cable. Be sure to observe proper polarity when connecting the load box to the power supply.

4. Remove the top cover from the NIDA 201 power supply and insert PCB 201-6 SCR Regulator.

5. Rotate the variable load control on the NIDA 201 load box to "min". Set the load selector switch to "var load".

6. Turn all controls on the front panel of the NIDA 201 power supply fully CCW.

NOTE: The coarse voltage control and the current control on the NIDA 201 power supply are not used in this Job Program.

7. Plug in and energize the NIDA 201 power supply.

8. Using the fine voltage control and the front panel voltmeter, determine the minimum and maximum voltages available from this power supply.

   ________VDC (min) ________VDC (max)

9. Rotate the fine voltage control CCW until 15 VDC is indicated on the front panel voltmeter.

10. Rotate the variable load control on the NIDA 201L load box for an indication of 0.6A on the front panel ammeter. This will be the reference voltage and current for the remainder of this Job Program.

11. Connect a 10X probe to the junction of R2 and R3.

    a. What is the purpose of this waveform? ____________________.

    b. Calculate the amplitude of this waveform. ____________volts.

12. Connect the remaining 10X probe to Pin #4 of the PCB which corresponds to the anode of Q3. Observe and draw both waveforms on the graticule in Figure 1. The step at the trailing edge is the firing point of the SCR's.

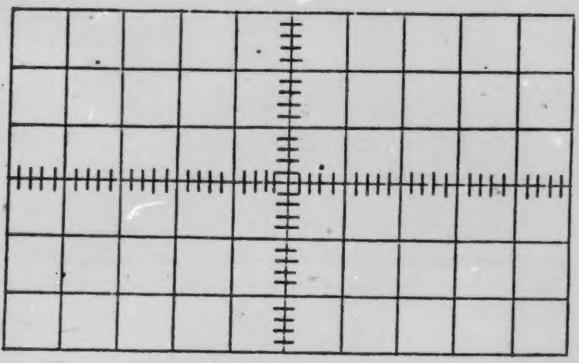


Figure 1

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13. The portion of the waveform following the firing point is the conduction time of the SCR in relation to the input waveform.

    a. What is the peak amplitude of the voltage at pin #4? _______volts.

    b. What is the peak amplitude of the voltage at pin #4 after the SCR conducts? ________ volts

    c. Calculate the time that the SCR conducts. ______________________.

14. Set the load control on the NIDA 201L load box for an indication of 0.9A on the front panel ammeter.

    a. What has happened to the voltmeter indication? increased/decreased/remained the same

    b. Is the output voltage being regulated as the load is varied? ________.

    c. Calculate the time that the SCR conducts. _______________.

15. Set the load control on the NIDA 201L load box for an indication of 0.3A on the front panel ammeter.

    a. What has happened to the voltmeter indication? increased/decreased/remained the same

    b. Is the output voltage still being regulated as the load is varied? ___________.

    c. Calculate the time that the SCR conducts. _______________.

16. Set the load control on the NIDA 201L for an indication of 0.9A on the front panel ammeter.

17. Slowly rotate the load control CCW while observing the waveform on the oscilloscope.

    a. What is happening to the conduction time of the SCR? ___________.

    b. What is happening to the amplitude of the waveform? ____________.

    c. Is the SCR firing earlier or later in the waveform? ____________.

NOTE: This should be sufficient for you to see that the greater the load current the longer the SCR will conduct. Since the output voltage was held constant and the current changed, then the power out will change. P = E x I.

NOTE: The reason that the DC (direct coupled) amplifier Q1 and the UJT were not covered previously in the Job Program was because the momentary change in output voltage due to load changes cannot be detected with the test equipment. The following procedure will manually change the output regulated voltage to allow observation of the DC amplifier and UJT circuit operation.

18. Set the fine voltage control to indicate 15 VDC. Set the load control on the NIDA 201L load box to indicate 0.6A on the front panel ammeter.

19. Measure and calculate the DC voltage on the collector of control amplifier Q1 and the time duration of the conduction of Q3.

__________VDC. __________.

20. Set the fine voltage control on the front panel fully CCW.

21. Measure and calculate the DC voltage on the collector of control amplifier Q1 and the time duration of the conduction of Q3.

__________VDC. __________.

22. Set the fine voltage control on the front panel fully CW.

23. Measure and calculate the DC voltage on the collector of control amplifier Q1 and the time duration of the conduction of Q3.

__________VDC. __________.

24. Connect the oscilloscope probe of channel #1 to the junction of R2 and R3 and the oscilloscope probe of channel #2 to pin #4 of the PCB.

25. Slowly rotate the fine voltage control on the front panel CCW, while observing the waveforms on the oscilloscope.

    a. What is happening to the conduction time of Q3? ________________.

    b. Is Q3 conducting earlier or later on the input waveform? ________.

    c. What is happening to the power out? ________________.

    d. What is happening to the amplitude of the gating pulse? ________.

26. Set the load selector switch on the NIDA 201L load box to lamps. Set all three toggle switches to the up position.

27. Slowly rotate the fine voltage control on the front panel of the power supply CW while observing the lamps. You can see that the SCR's are acting like a light dimmer switch installed in many homes.

    a. What is happening to the conduction time of the SCR's? ________.

b. Are the SCR's conducting earlier or later on the input waveform?

___________.

28. Set the fine voltage control on the NIDA Power Supply to mid-range.

29. Set the loud box selector switch to "var. load"

30. Set the loud control on the NIDA 201L Loud Box to mid-range

31. Measure the DC voltages at the following test points and compare your results with references on pg. 315. Explain any differences.

Anode Q3
TP 1

V_E Q1

TP 2

TP 3

TP 4

Pin 22

Pin 20

Pin 19

You have now completed the Job Program for SCR Regulated Power Supplies. You should have noticed that by changing the load or changing the output voltage you can change the conduction time of the SCR's thereby changing the power out. SCR Q4 operates exactly the same as SCR Q3 which is why it was not discussed in the Job Program.

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON TEST. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

FAULT ANALYSIS

(PAPER TROUBLESHOOTING)

FOR

MODULE 30, LESSON 4

NOW THAT YOU HAVE COMPLETED THE KNOWLEDGE SECTION OF THIS LESSON, YOU ARE READY FOR PAPER TROUBLESHOOTING.

THE COMPUTER WILL ASSIGN YOU A SET OF PAPER TROUBLESHOOTING PROBLEMS ON THE SCR REGULATOR. THESE PROBLEMS WILL HELP YOU DEVELOP THE MENTAL SKILLS REQUIRED IN ACTUAL TROUBLESHOOTING. YOU WILL BE GIVEN SYMPTOMS OF A FAILURE AND CIRCUIT MEASUREMENTS THAT WILL ALLOW YOU TO IDENTIFY THE PROBLEM.

AFTER YOU COMPLETE THE PAPER TROUBLESHOOTING SECTION, THE COMPUTER WILL ASSIGN YOU A PRACTICE TROUBLESHOOTING PROBLEM ON A FAULTY PRINTED CIRCUIT BOARD.

REMEMBER THAT REFERENCE VOLTAGES, WAVEFORMS, AND A SCHEMATIC ARE CONTAINED IN THIS STUDENT GUIDE FOR YOUR USE IN BOTH PAPER AND ACTUAL TROUBLESHOOTING PROBLEMS.

TERMINAL OBJECTIVE:

30.4.51 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a regulated SCR power supply circuit when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

ENABLING OBJECTIVE:

30.3.50 IDENTIFY the schematic diagrams, component functions, and operational principles of SCR power supply circuits, including the relationship between the conduction time of an SCR and the DC output voltage, by selecting statements from a choice of four.

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OVERALL PERFORMANCE TEST INSTRUCTIONS
FOR
TROUBLESHOOTING PERFORMANCE TEST

INTRODUCTION:

Using the following six step troubleshooting procedure will aid you in determining which component is faulty. In the split method of troubleshooting, the top of R7 which corresponds to base 1 of the UJT, has been selected as the starting point for dividing the circuit in half. Based on your interpretation of the scope presentation at this point, you can determine which direction you should go.

EQUIPMENT:

1. NIDA 201 Power Supply
2. NIDA 201L Load Box
3. NIDA 201-6 Printed Circuit Board
4. Oscilloscope
5. 10 X 1 Oscilloscope Probes (2)
6. Simpson 260 Multimeter
7. 1 Pair of Multimeter Test Leads

INSTRUCTIONS:

1. Each student is required to determine the defective component in a prefaulted SCR Regulated Power Supply. You will be allowed 45 minutes of troubleshooting time on the equipment.

2. Standard test equipment will be available to you in the form of an oscilloscope, and a Simpson 260 multimeter. You will be expected to observe all safety precautions throughout the test. A safety violation will result in an automatic failure of the performance test. In that event you will be counselled and given remedial training.

3. You will take a numbered position in the test room. After a briefing by the Learning Center Instructor you will fill out the heading of the troubleshooting form. On a signal from the Learning Center Instructor you will then start the test. If at any time during the test you should require assistance raise your hand. DO NOT LEAVE YOUR POSITION. A Learning Center Instructor will assist you with your trouble.

4. You must identify the faulty component to pass this test.

5. If you do not understand these instructions raise your hand and ask your Learning Center Instructor. If you do understand these instructions and upon a signal from your Learning Center Instructor you may now begin the performance test on the next page.

SIX STEP TROUBLESHOOTING PROCEDURES

FOR

TROUBLESHOOTING PERFORMANCE TEST

DIRECTIONS: DO NOT WRITE IN THE PERFORMANCE TEST BOOKLET. MAKE ALL YOUR RESPONSES ON THE SIX STEP TROUBLESHOOTING SHEET SUPPLIED WITH THIS TEST PACKET. THIS PERFORMANCE TEST BOOKLET IS DESIGNED TO AID YOU IN COMPLETING THE STANDARD SIX STEP TROUBLESHOOTING FORM. COMPLETE THE STEPS USING YOUR KNOWLEDGE AND SKILL OF THIS CIRCUIT. SUGGESTIONS FOR COMPLETING THE STEPS ARE PROVIDED IN THIS BOOKLET. CONTACT YOUR LEARNING CENTER INSTRUCTOR IF YOU HAVE ANY QUESTIONS.

SET THE FINE VOLTAGE CONTROL ON THE NIDA 201 POWER SUPPLY TO MIDRANGE. SET THE LOAD CONTROL ON THE NIDA 201L LOAD BOX TO MIDRANGE. INSERT THE PREFAULTED PRINTED CIRCUIT BOARD OF THE SCR REGULATED POWER SUPPLY PCB201-6 AND ENERGIZE THE EQUIPMENT. THE NORMAL READING ON THE FRONT PANEL METERS FOR THE ABOVE SETTINGS IS 9.2 VDC, 0.2A APPROXIMATELY.

STEP ONE - SYMPTOM RECOGNITION

1. Does the equipment energize?

STEP TWO - SYMPTOM ELABORATION

1. What do the front panel meters indicate?
   a. Normal
   b. High
   c. Low
   d Zero

STEP THREE - LIST THE PROBABLE FAULTY FUNCTION(S)

1. There are four functions to this circuit.
   a. SCR Power Supply
   b. Control Amplifier Q1
   c. Pulse Generator Q2
   d Voltage Regulator CR1

STEP FOUR - LOCALIZE THE FAULTY FUNCTION

1. Verify the probable faulty function by using your test equipment.
2. List the test points where voltages/waveforms were obtained.
3. Reference voltages and waveforms are listed in voltage/waveform charts.
4. Which function listed in step three above is the faulty function?

TROUBLESHOOTING PERFORMANCE TEST

STEP FIVE - LOCALIZE THE FAULTY CIRCUIT/COMPONENT

1. List the test points where actual voltages/waveforms were taken.
2. What circuit/component in the faulty function listed in step four is faulty?
3. If you have determined the faulty circuit but not the faulty component proceed to step six.

STEP SIX - FAILURE ANALYSIS

1. Secure the power and using the Simpson 260 take resistance checks.
   a. Check front to back ratios in transistors and diodes.
   b. Take continuity checks on printed circuit board foil.
   c. Capacitors can be shorted or open.
   d. Resistors can be open.
2. Explain in your own words why the component listed in steps five or six above would cause the symptoms listed in steps one and two of the six step troubleshooting procedures? Write your answer in the space provided below.

NOTE: IN STEPS 4,5, AND 6, LIST THE REFERENCE (WAVEFORM, VOLTAGE, RESISTANCE) FOR EACH MEASUREMENT ON THE SIX STEP TROUBLESHOOTING SHEET.

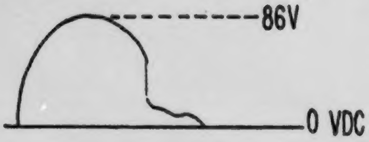
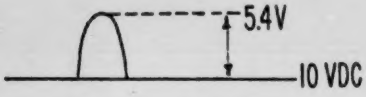
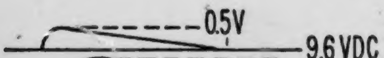
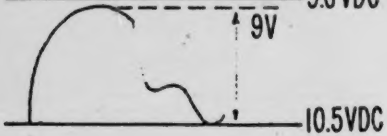
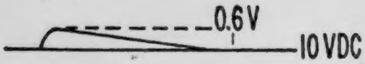
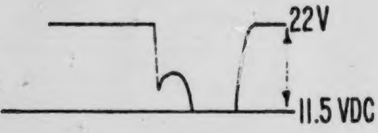
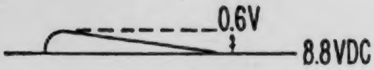
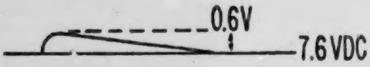
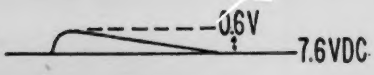
TAKE YOUR SIX STEP TROUBLESHOOTING SHEET TO YOUR LEARNING CENTER INSTRUCTOR FOR VERIFICATION AND EVALUATION.

TROUBLESHOOTING VOLTAGE/WAVEFORM CHART

FOR

SCR REGULATED POWER SUPPLY

These voltages/waveforms were measured in a properly operating SCR Regulated Power Supply. The voltages on the waveforms were calculated from an oscilloscope display. The DC voltages on the voltage chart were taken with a Simpson 260 multimeter. The front panel settings were load control at midrange and the fine voltage control at midrange.

TEST POINT	WAVEFORMS	DC VOLTAGE
Anode Q3		27.3 VDC
TP1		10.6 VDC
V_E Q1		9.2 VDC
TP2		15.3 VDC
TP3		10.2 VDC
TP4		20.0 VDC
Pin #22		9.4 VDC
Pin #20		7.8 VDC
Pin #19		6.3 VDC

SCHEMATIC DIAGRAM

SCR REGULATED POWER SUPPLY

PC 201-6

P.P. 115, 116

SUMMARY
LESSON 1

RF, IF, and Video Amplifier Characteristics

RF, IF, and video amplifiers are important in communication and radar electronic equipment. Two major categories of information in a basic transmit-receive system are audio signals (20 Hz to 20,000 Hz) and video signals (0 Hz to 6 MHz). Amplifiers you have studied were in the audio frequency response range and were designed to amplify about equally well any signal within that range.

This lesson describes some important operating characteristics of amplifiers. Recall that frequency response is expressed as two numbers, the upper Fco (cut-off frequency) and lower Fco, while bandwidth is expressed as the difference between them. The amplitude of an output signal has its maximum (100%) gain at the center, or resonant frequency (Fo). The upper and lower Fcos, or half-power points, define the two frequencies at which the output voltage amplitudes are reduced to 70.7% of the maximum gain.

These amplifier characteristics can be presented in a frequency response curve as shown in Figure 1.

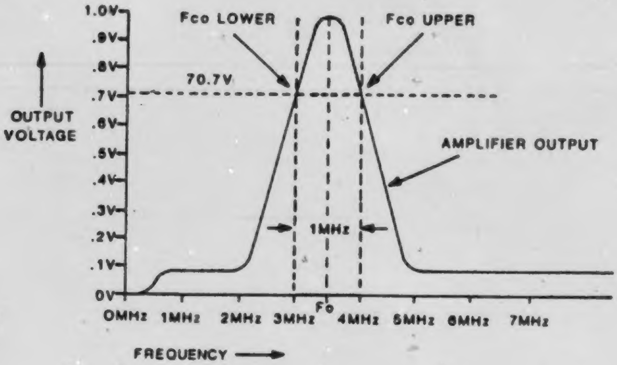


Figure 1

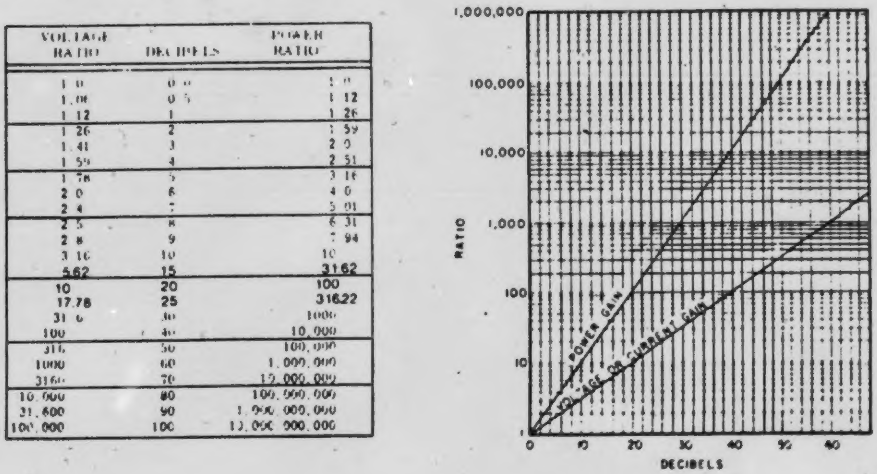
FREQUENCY RESPONSE CURVE

In this example, the voltage output at Fo equals .1 volt input X gain of 10, or 1 volt. Therefore voltage output at the half-power points equals .707 volts. The frequency response is 3 MHz to 4 MHz and the bandwidth 1 MHz. Signal amplification outside of the frequency response is normally considered as an unusable output.

RF amplifiers have about any frequency response characteristic and bandwidth within the frequency range 30 kHz to 300 GHz (G is giga and means 10^9). They are either untuned producing a broad bandwidth, or variably tuned producing a narrow bandwidth over chosen center frequencies. The amplifier's selectivity separates and amplifies a chosen signal and excludes most others.

IF amplifiers are basically fixed-tuned RF amplifiers with a relatively narrow bandwidth. The frequency range is similar to RF amplifiers. Video amplifiers are untuned with a frequency response from about 0 Hz to near 6 MHz and are useful in amplifying square or sawtooth waves.

In electronics, a measurement unit called the decibel (dB) is used to simplify solving such problems as combining amplifier gains (i.e., the ratio of output over input). Voltage and power gains can be converted to equivalent decibel values by the use of charts and/or graphs as shown in Figure 2.



VOLTAGE RATIO	DECIBELS	POWER RATIO
1.0	0.0	1.0
1.06	0.5	1.12
1.12	1	1.26
1.26	2	1.59
1.41	3	2.0
1.59	4	2.51
1.78	5	3.16
2.0	6	4.0
2.4	7	5.01
2.5	8	6.31
2.8	9	7.94
3.16	10	10
5.62	15	31.62
10	20	100
17.78	25	316.22
31.6	30	1000
100	40	10,000
316	50	100,000
1000	60	1,000,000
3160	70	10,000,000
10,000	80	100,000,000
31,600	90	1,000,000,000
100,000	100	10,000,000,000

Figure 2

DECIBEL CHART/GRAPH

Inspection of Figure 2 shows that voltage and power ratios convert to different decibel values.

A typical problem which involves combining decibels is to find the total circuit voltage gain of several amplifiers connected in series, or "cascade", as shown in Figure 3.

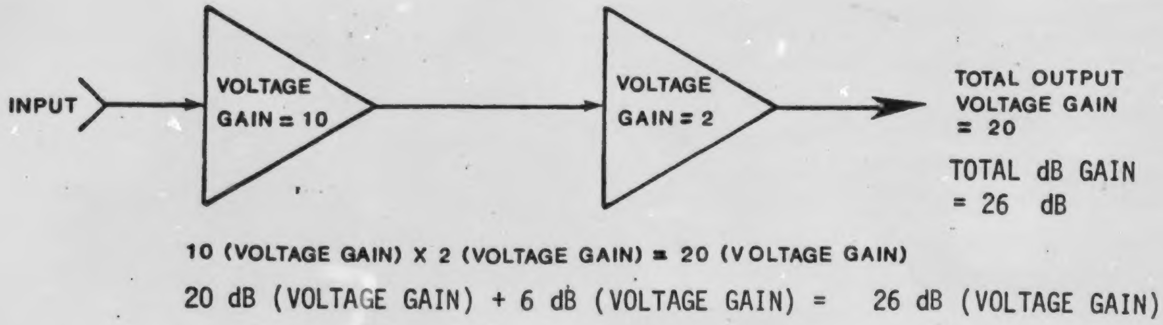

INPUT
VOLTAGE GAIN = 10
VOLTAGE GAIN = 2
TOTAL OUTPUT VOLTAGE GAIN = 20
TOTAL dB GAIN = 26 dB
10 (VOLTAGE GAIN) X 2 (VOLTAGE GAIN) = 20 (VOLTAGE GAIN)
20 dB (VOLTAGE GAIN) + 6 dB (VOLTAGE GAIN) = 26 dB (VOLTAGE GAIN)

Figure 3

CASCADED VOLTAGE AMPLIFIERS--VOLTAGE AND DECIBEL GAIN

In the example, the total circuit voltage gain equals the product of the individual amplifier voltage gains or 20 as shown. If the individual amplifier voltage gains are first converted to their decibel values, the total circuit voltage gain equals the sum of the individual amplifier dB gains. The identical procedure of converting gains to decibels and summing decibels can be used to find total circuit output power gain.

Another common decibel application is to find an amplifier voltage or power output signal, given the input signal and decibel gain. A diagram of a simple problem is shown in Figure 4.

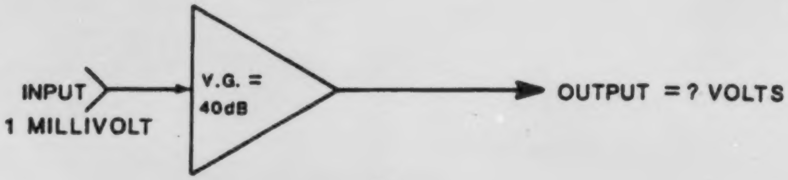

INPUT
1 MILLIVOLT
V.G. = 40dB
OUTPUT = ? VOLTS

Figure 4

VOLTAGE OUTPUT VS INPUT USING DECIBLES

In this example, the dB gain is converted back to a voltage gain of 100. The product of 100 X 1 millivolt input equals the output, or 100 millivolts. The same procedure is followed to find an amplifier output signal, given the input signal and decibel power gain.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, THEN YOU MAY TAKE THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK

LESSON 1

RF, IF and Video Amplifier Characteristics

TERMINAL OBJECTIVE(S):

31.1.52 When the student completes this lesson, (s)he will be able to: IDENTIFY basic operating characteristics of RF, IF, and video amplifiers to include selecting definitions of terms, determining amplifier frequency response curve values, and determining amplifier voltage and power decibel gain, by selecting values or statements from a choice of four. 100% accuracy is required.

ENABLING OBJECTIVE(S):

When the student completes this lesson (s)he will be able to:

31.1.52.1 DEFINE the general characteristics of an amplifier, to include center frequency (fo), cutoff frequency (fco), frequency response, and bandwidth, which are shown in a frequency response curve, by selecting the correct definition from a choice of four. 100% accuracy is required.

31.1.52.2 DETERMINE the frequency response characteristics of an amplifier, given its frequency response curve, by selecting the correct statement from a choice of four. 100% accuracy is required.

31.1.52.3 DEFINE the term "selectivity" as it applies to RF, IF, and video amplifiers by selecting the correct definition from a choice of four. 100% accuracy is required.

31.1.52.4 IDENTIFY the general operating characteristics of RF, IF, and video amplifiers, including frequency range, selectivity, and tuning, by selecting the correct statement from a choice of four. 100% accuracy is required.

31.1.52.5 CONVERT given amplifier voltage and power gain ratios to decibels (dB), and vice versa, given a decibel conversion chart/graph, by selecting the correct value(s) from a set of four choices. 100% accuracy is required.

31.1.52.6 DETERMINE total gain and output levels (in terms of voltage, power, or decibels) for a given single or cascaded amplifier circuit when provided a decibel conversion chart/graph and input data, by selecting the correct value(s) from a set of four choices. 100% accuracy is required.

PROGRESS CHECK
LESSON 1

RF, IF and Video Amplifier Characteristics

1. Video signals are associated with __________ information and audio signals with __________ information.

   a. sound, picture
   b. visual, sound
   c. amplifier, bandwidth
   d. training, fixed

2. The difference between the upper and lower Fco's in an amplifier is called the

   a. frequency response
   b. half-power point
   c. bandwidth
   d. amplitude

3. The gain of an amplifier's output signal is maximum at the

   a. upper Fco
   b. lower Fco
   c. Fo
   d. bandwidth

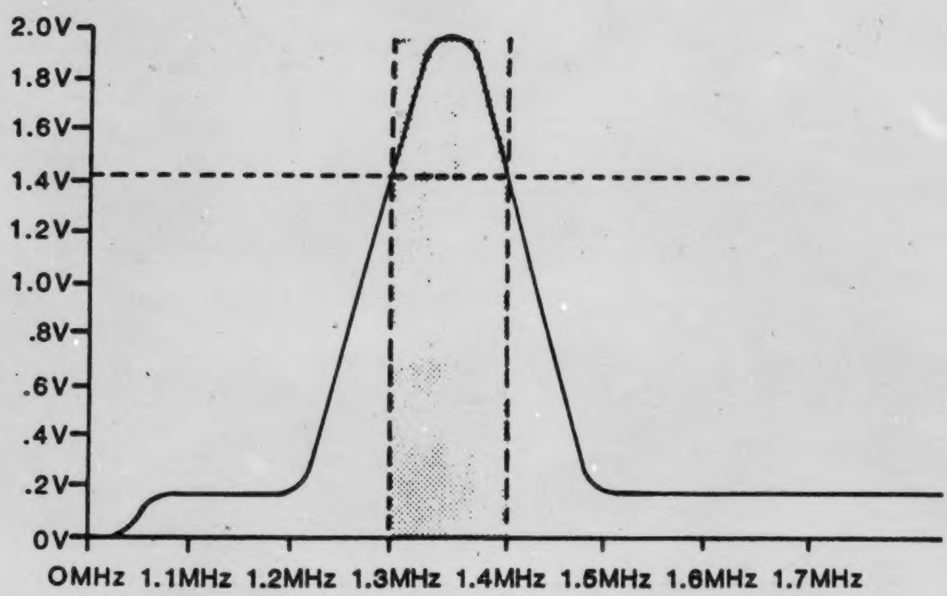
4. An amplifier has a maximum output of 3 volts for a given input signal. What is the output at the half-power points?

   a. 1.5 volts
   b. 2.1 volts
   c. 3.0 volts
   d. 4.2 volts

5. Which type of amplifier is tuned to a specific fixed frequency?

   a. IF
   b. RF
   c. Video

STUDY THE FREQUENCY RESPONSE CURVE BELOW AND ANSWER QUESTIONS 6 THRU 8.



6. What is the bandwidth?

   a. 1.4 MHz
   b. 1.35 MHz
   c. 1 MHz
   d. .1 MHz

7. What is the approximate output voltage at the upper Fco?

   a. 2.0 volts
   b. 1.4 volts
   c. 1.0 volt
   d. .6 volt

8. A 2.0 volt output is obtained at the

   a. center frequency
   b. upper Fco
   c. lower Fco
   d. half-power points

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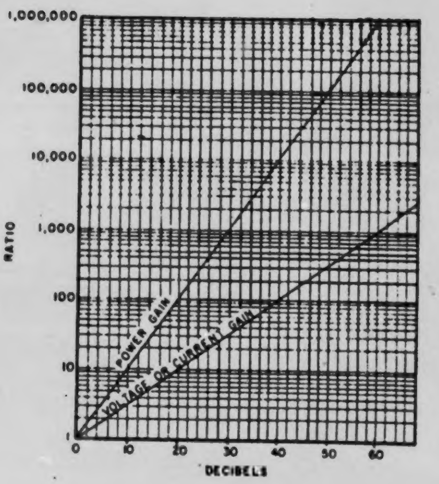
QUESTIONS 9 THROUGH 12 MAY REQUIRE YOU TO USE THE dB CHART OR dB GRAPH BELOW.

VOLTAGE RATIO	DECIBELS	POWER RATIO
1.0	0.0	1.0
1.06	0.5	1.12
1.12	1	1.26
1.26	2	1.59
1.41	3	2.0
1.59	4	2.51
1.78	5	3.16
2.0	6	4.0
2.4	7	5.01
2.5	8	6.31
2.8	9	7.94
3.16	10	10.
5.62	15	31.62
10	20	100
17.78	25	316.22
31.6	30	1000
100	40	10,000
316	50	100,000
1000	60	1,000,000
3160	70	10,000,000
10,000	80	100,000,000
31,600	90	1,000,000,000
100,000	100	10,000,000,000



9. An amplifier with a voltage gain of 100 converts to a gain of _______ dB.

   a. 10
   b. 20
   \ c. 30
   d. 40

10. Three amplifiers are connected in series. They have voltage gains of 100, 10, and 2 respectively. What is the total circuit voltage gain in decibels?

    a. 33 dB
    b. 66 dB
    c. 112 dB
    d. 600 dB

11. Two amplifiers are connected in series. They have power gains of 10 dB and 5 dB, respectively. What is the total circuit power gain in decibels?

    a. .5 dB
    b. 2 dB
    c. 15 dB
    d. 50 dB

12. An amplifier has an input of 1 volt and a voltage gain of 6 decibels. What is the output voltage?

    a. 2 volts
    b. 4 volts
    c. approximately 8 volts
    d. approximately 16 volts

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY AND FEEL READY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL OR MOST OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

SUMMARY
LESSON 2

RF Amplifiers

Amplifiers are called RF amplifiers only because they have untuned or tuned input and output coupling with a frequency response in the RF range. Tuned coupling is more common because we are usually interested in the RF amplifier's selectivity when we tune to a specific station on a radio receiver.

Transformers can be made into tuned parallel resonant coupling circuits by placing a capacitor across either or both windings. An example using tuned coupling transformers in a basic amplifier circuit is shown in Figure 1.

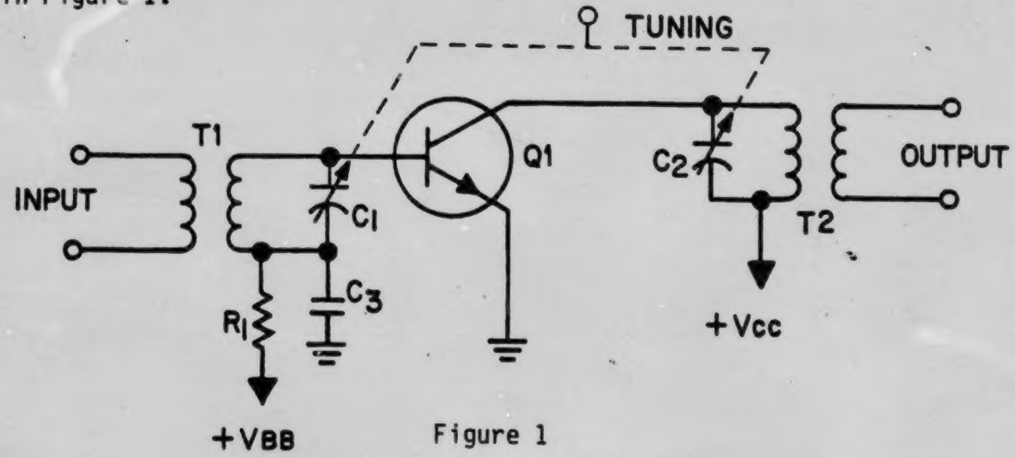


Figure 1

TUNED RF AMPLIFIER

If all the resonant circuits are tuned to the same frequency, the signal input to Q1 and signal output from T2 will be maximum at that Fo.

Amplifier selectivity is directly related to the number of circuits tuned to the same frequency in the amplifier's signal path. This relationship is shown in Figure 2.

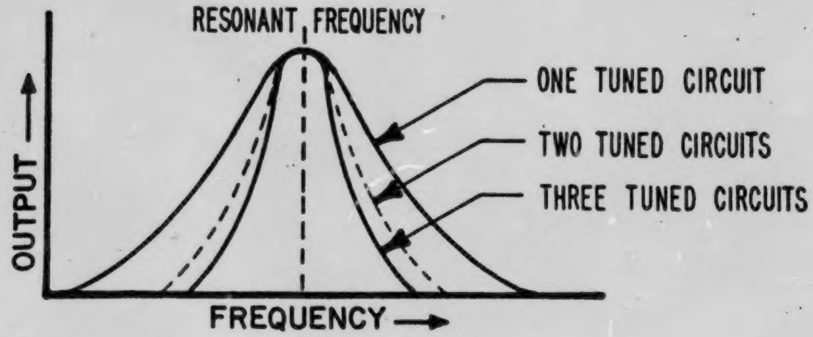


Figure 2

RF AMPLIFIER FREQUENCY RESPONSE CURVES

The input and output coupling tanks can be variable tuned at the same time if the capacitors or inductors are connected together, or "ganged". Figure 3 shows a circuit with ganged variable capacitors.

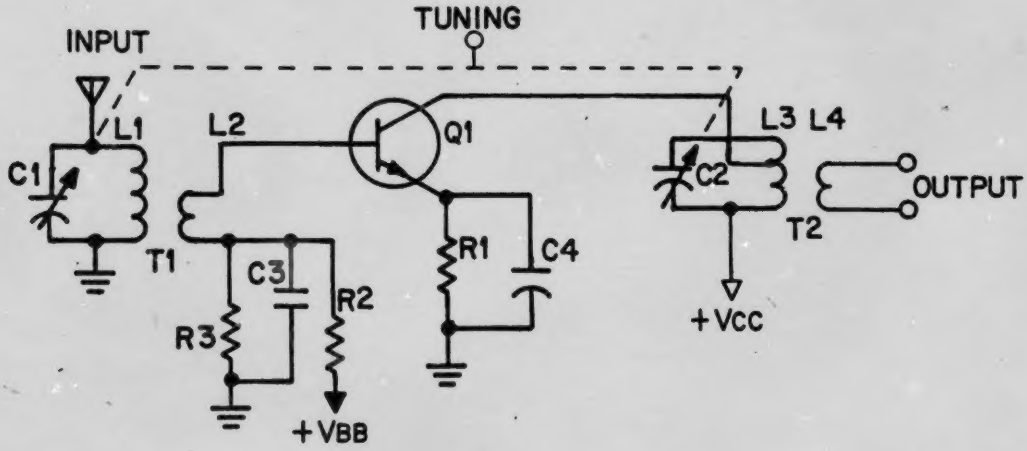

TUNING
INPUT
L1
C1
T1
L2
C3
R3
R2
+VBB
Q1
R1
C4
L3 L4
C2
T2
+VCC
OUTPUT

Figure 3

GANGED CAPACITIVE TUNING

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Capacitors may be ganged by gears, pulleys, and most often by a common shaft.

Figure 4 shows schematics and a pictorial view of an individual inductive tuned RF transformer.

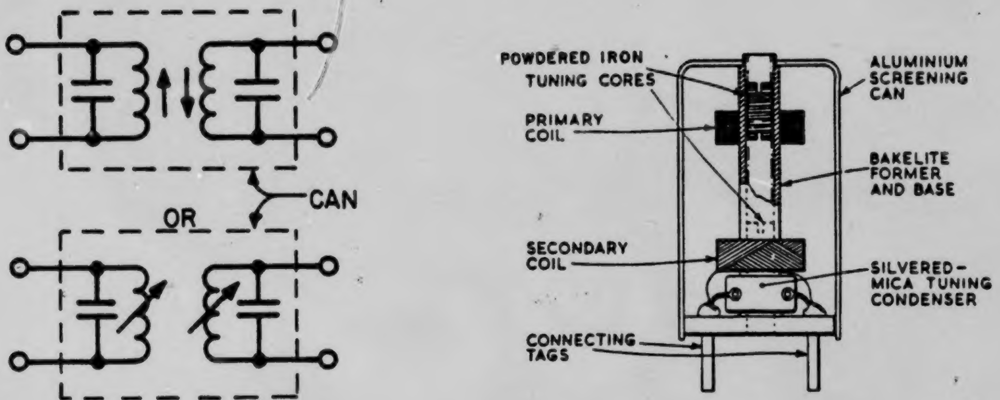

CAN
OR
POWDERED IRON TUNING CORES
PRIMARY COIL
SECONDARY COIL
CONNECTING TAGS
ALUMINIUM SCREENING CAN
BAKELITE FORMER AND BASE
SILVERED-MICA TUNING CONDENSER

Figure 4

INDUCTIVE TUNED RF TRANSFORMER

The primary and secondary windings can be independently tuned. The entire unit is completely enclosed within a metallic shield. This device is very common in radio receivers and transmitters.

Transformer coupling is inefficient for higher RF signals. To get around this problem, the modified coupling circuit in Figure 5 retains the selectivity advantages of the parallel resonant circuit. C3 provides additional coupling between L1 and L2.

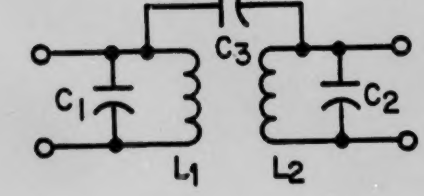

C3
C1
C2
L1
L2

Figure 5

CAPACITIVE COUPLED TUNED TANKS

The Q of an inductor, tank, or loaded circuit expresses the relationships between inductive reactance (XL), capacitive reactance (XC), and resistance (R). The Value Q, or quality, represents the ratio of "energy stored/energy used". Figure 6 shows the inductor equivalent for XL and Rc (coil resistance).

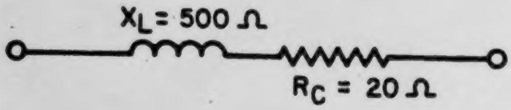


Figure 6

INDUCTOR EQUIVALENT

The formula for Q of a coil is Qcoil = XL divided by Rc, or 25 in the example. Figure 7 shows a simple LC tank circuit.

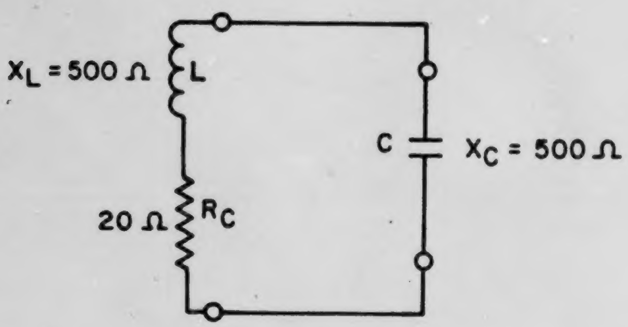


Figure 7

TANK CIRCUIT

In the tank, both XL and XC are equivalent expressions for energy stored. Therefore, the formula for Q of the tank is Qtank = XL (or XC) divided by Rc, or 25 in the example.

Bandwidth can be determined by the formula BW = Fo divided by Q tank. The relationship between the Q of a tank and bandwidth can be seen in the tank circuit diagram and tank frequency response curve in Figure 8.

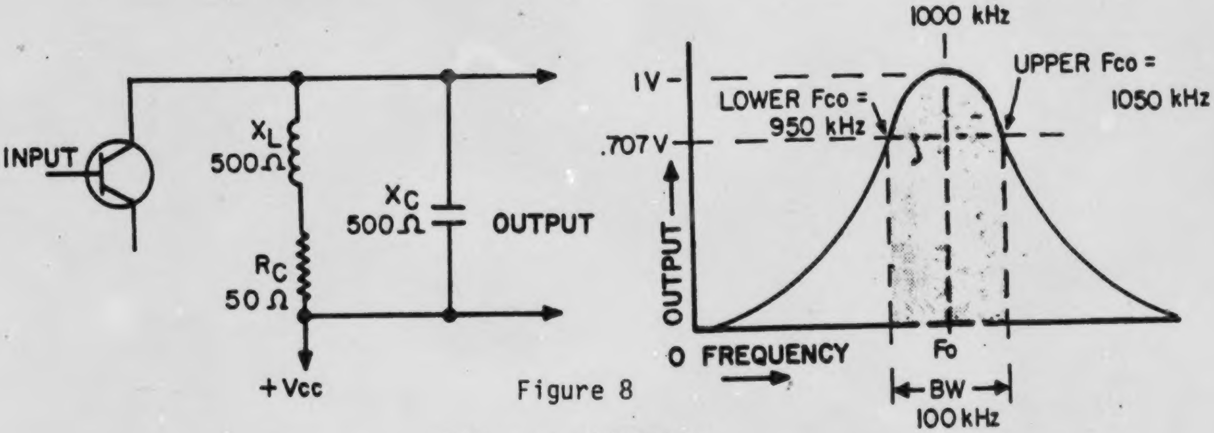

INPUT
X_L 500Ω
R_C 50Ω
X_C 500Ω
OUTPUT
+Vcc
1000 kHz
1V
.707V
LOWER Fco = 950 kHz
UPPER Fco = 1050 kHz
OUTPUT
0 FREQUENCY
Fo
BW 100 kHz

Figure 8

TANK Q vs BANDWIDTH

The figure shows a 40 kHz bandwidth. You can calculate the bandwidth by plugging the circuit diagram values into the formula for Q and bandwidth. In the example, Q equals 25, and bandwidth equals 1000 kHz divided by Q, or 40 kHz. The steep sides, or skirts, on the frequency response curve indicate that the Q of the tank produces high selectivity. If the coil resistance in the tank increases while XL, XC, and Fo remain constant, the Q would lower and the bandwidth would widen. Coil resistance can be increased by winding coils of the same XL with smaller diameter wire.

Figure 9 shows a loaded circuit which includes a tank, switch, and parallel load (Rp).

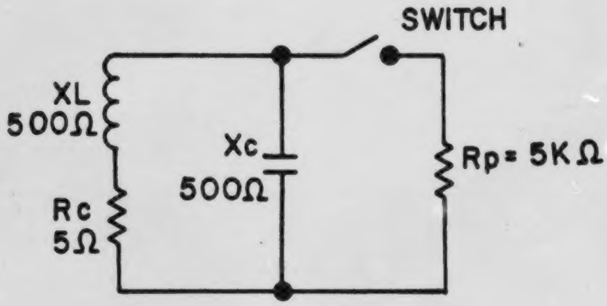

SWITCH
XL 500Ω
Rc 5Ω
Xc 500Ω
Rp = 5KΩ

Figure 9

LOADED CIRCUIT

When the switch is open, the Q of the unloaded tank is expressed by the familiar ratio XL (or XC) divided by Rc, or 100 in the example. When the switch is closed, the Q of the loaded tank circuit is Q ckt = Rp divided by XL (or XC), or 10 in the example. The Q of the circuit will be lower when a load is placed on a tank than the Q of the tank without a load. In wideband RF amplifiers, "swamping" resistors sometimes are placed across tank circuits to purposely lower the Q of the circuit and widen the bandwidth.

Figure 10 shows a typical RF amplifier input stage in a broadcast band radio receiver.

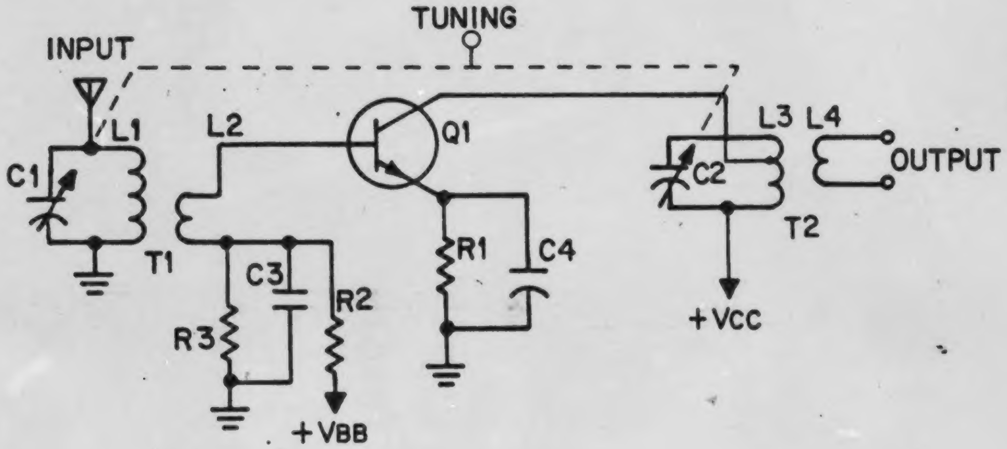


Figure 10

TYPICAL TUNED RF AMPLIFIER

R2 and R3 form a voltage divider to provide forward bias for Q1. C3 places the bottom of L2 at RF ground potential and ensures all signal development is across L2. T1 is a step-down transformer with the low impedance winding L2 connected to the base of Q1. This impedance match provides for maximum energy transfer between the antenna and base of Q1, and also preserves the Q of the L1-C1 tank.

Both the Q and selectivity of tank L3-C2 are preserved in a similar manner. The technique of tapping L3 provides a good impedance match between the collector of Q1 and tank L3-C2. Therefore maximum energy transfer occurs between the output of Q1 and the input to the following stage. Note that V_{BB} and V_{CC} are often one and the same source.

In Figure 10, tank L1-C1 selects one of the many frequencies received by the antenna. The signal then is coupled to L2, fed into the base of Q1, amplified, and coupled by T2 to the next stage.

Figure 11 shows one of the many different ways the amplifier circuit in Figure 10 can be drawn.

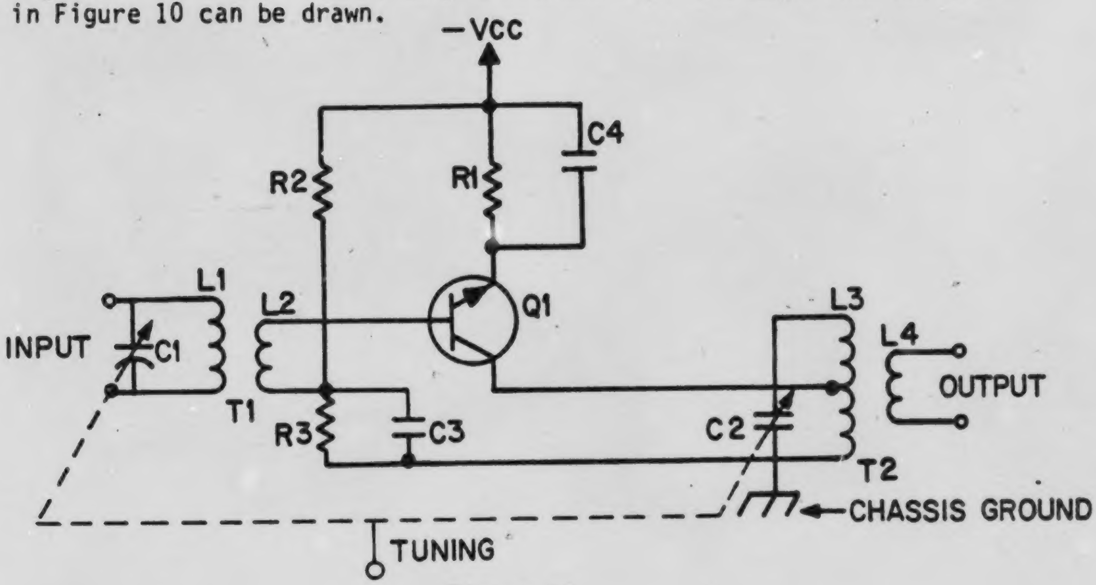

−VCC
C4
R2
R1
L1
L2
Q1
L3
L4
INPUT
C1
OUTPUT
T1
R3
C3
C2
T2
CHASSIS GROUND
TUNING

Figure 11

TUNED RF AMPLIFIER

One minor difference is that the tank L3-C2 in Figure 11 is grounded on one side allowing easy attachment of the capacitor frame to the chassis.

Transistors in tuned RF amplifiers have an internal regenerative feedback circuit which may cause oscillation at the higher frequencies. This internal regenerative feedback path is shown in the shaded area of Figure 12.

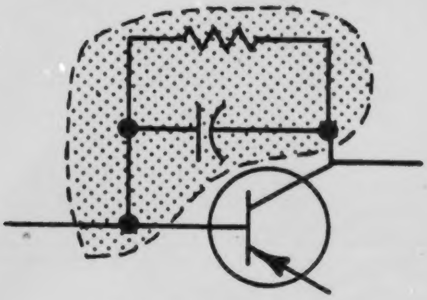


Figure 12

TRANSISTOR INTERNAL FEEDBACK

We can neutralize this internal feedback, and prevent oscillation, by connecting an external feedback circuit which produces a voltage equal in amplitude and opposite in polarity to the internal feedback voltage. Figure 13 shows two types of amplifier neutralization circuits, each labeled Cn.

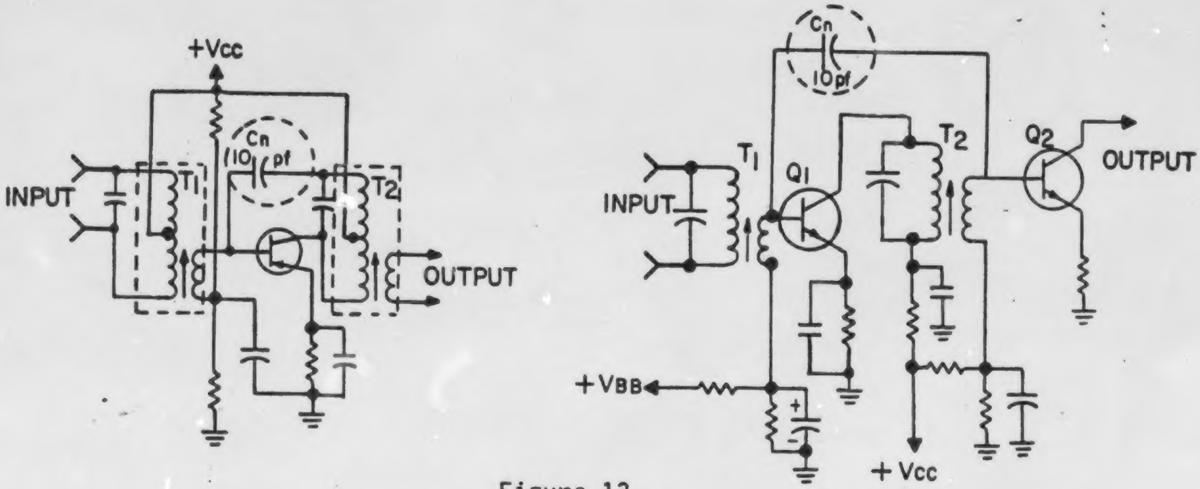

+Vcc
INPUT
T1
Cn
10 pf
T2
OUTPUT
Cn
10pf
T1
Q1
T2
Q2
OUTPUT
INPUT
+VBB
+
-
+Vcc

Figure 13

TYPICAL NEUTRALIZING CIRCUITS

RF amplifiers are designed to take into consideration any "stray reactances" at high frequencies caused by the position of wires and components in relation to the chassis. The capacitances Co and Cin in Figure 14 are examples of stray reactances.

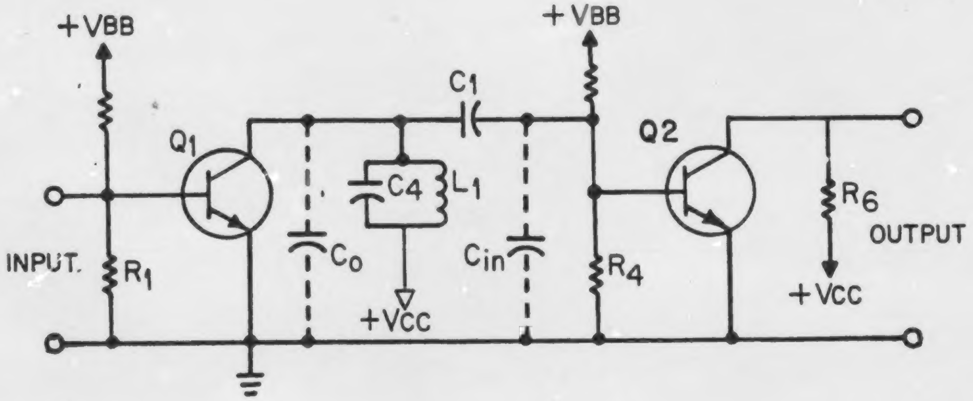

+VBB
+VBB
C1
Q1
Q2
C4
L1
INPUT
R1
Co
Cin
R4
R6
OUTPUT
+VCC
+VCC

Figure 14

STRAY REACTANCES IN RF AMPLIFIER CIRCUIT

You must be neat and cautious when you repair a circuit so that replaced components will be positioned as they were before repair. Otherwise you may cause a frequency change or oscillation in the amplifier.

Amplifiers can be biased to operate either Class A, B, AB, or C. Figure 15 shows the signal input, transistor conduction waveform and time, and signal output for one cycle in Class A and Class B amplifiers (CE) with resistive loads.

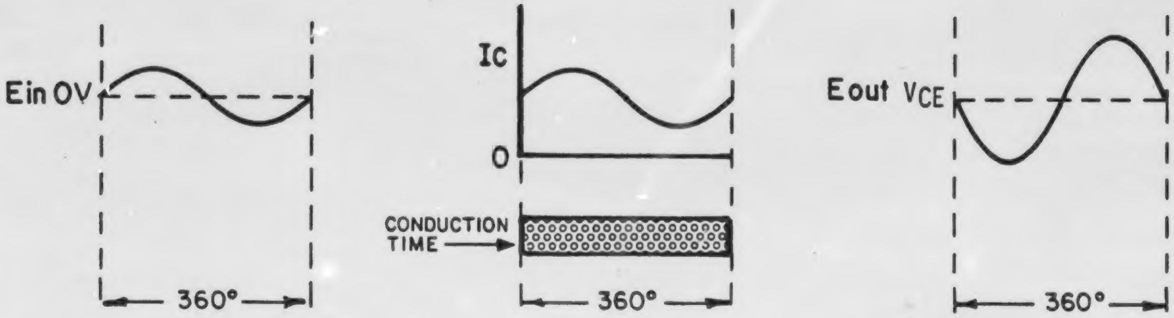

Ein OV
360°
Ic
0
CONDUCTION TIME
360°
Eout VCE
360°

Figure 15

CLASS A OPERATION

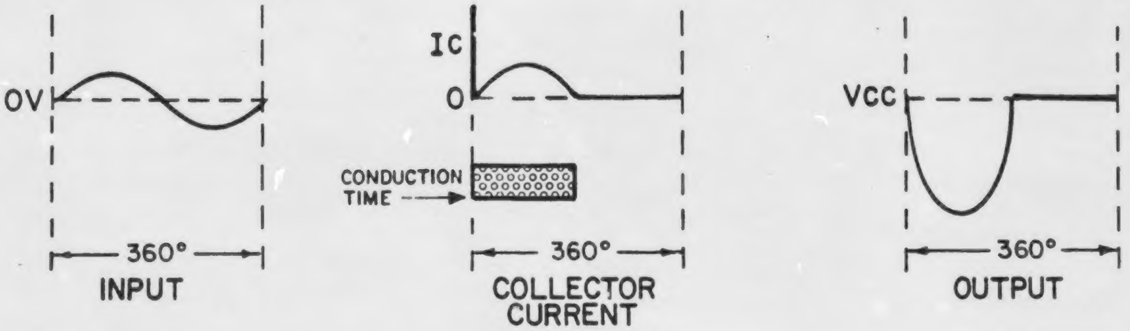

OV
360°
INPUT
Ic
0
CONDUCTION TIME
360°
COLLECTOR CURRENT
VCC
360°
OUTPUT

Figure 15

CLASS B OPERATION

In Class A amplifiers, the forward bias is set high enough so that the transistor conducts over the entire input cycle. In Class B amplifiers, the bias is set near zero which causes the transistor to conduct for about half the input cycle. This produces a clipped, or distorted, output signal. The reduced conduction time makes Class B amplifiers more efficient than Class A amplifiers.

Figure 16 shows the operation for Class AB and Class C amplifiers with resistive loads.

In Class AB amplifiers, the bias is set to cause the transistor to conduct for between 180° and 360° of the input cycle. Class AB amplifiers have less output distortion, but lower efficiency, than Class B amplifiers.

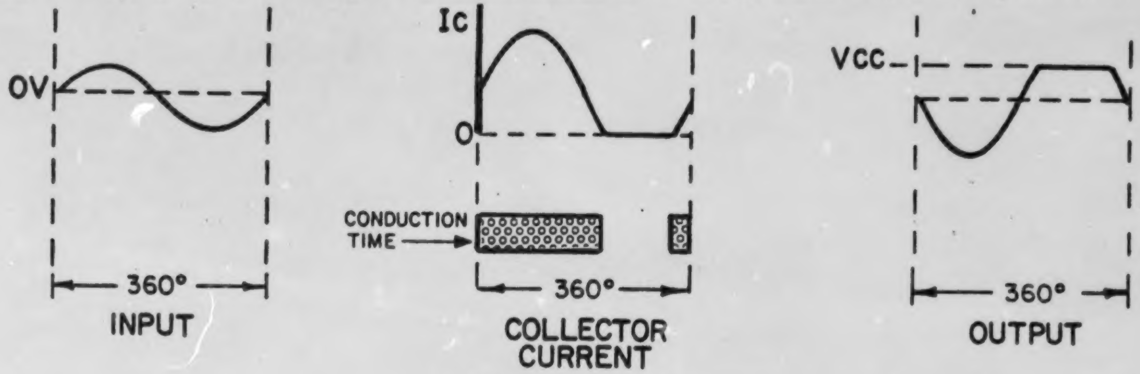

OV
360°
INPUT
Ic
O
CONDUCTION TIME
360°
COLLECTOR CURRENT
VCC
360°
OUTPUT

Figure 16

CLASS AB OPERATION

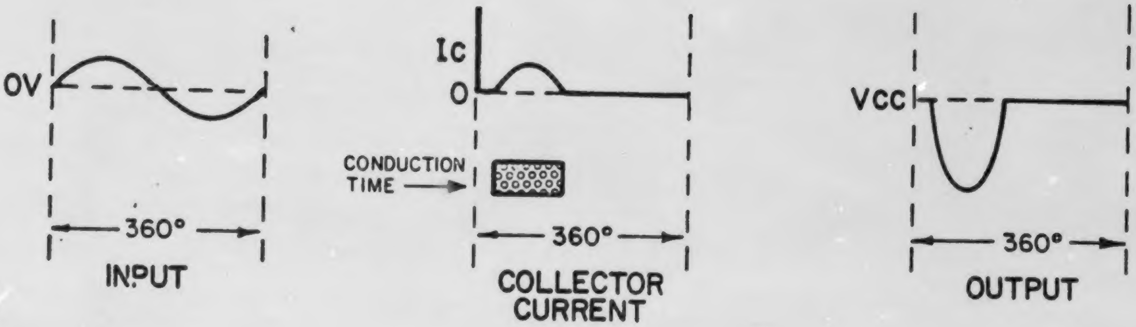

OV
360°
INPUT
Ic
O
CONDUCTION TIME
360°
COLLECTOR CURRENT
VCC
360°
OUTPUT

Figure 16

CLASS C OPERATIONS

In Class C amplifiers, the reverse bias causes the transistor to conduct for about 120° of the input cycle.

Class C amplifiers have the greatest output signal distortion, but the greatest efficiency of the four operating classes. Figure 17 shows an application of a Class C amplifier circuit.

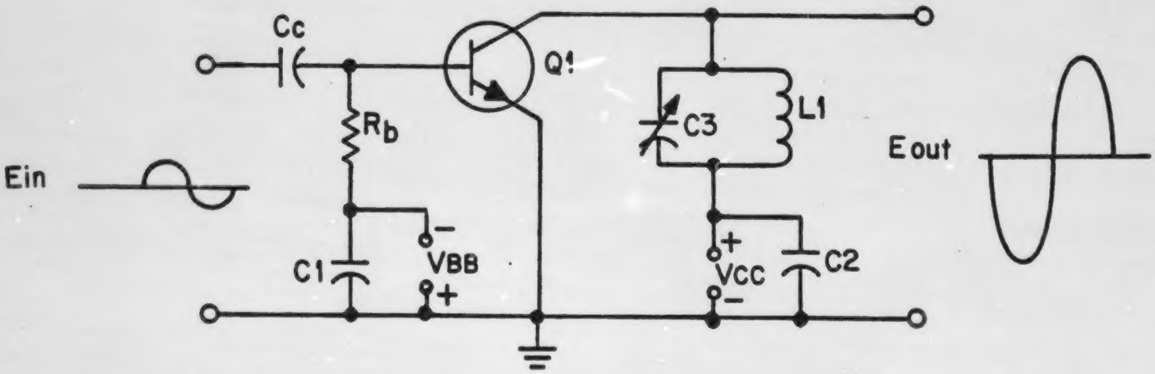

Cc
Q1
Rb
C3
L1
Eout
Ein
C1
VBB
+
–
Vcc
C2

Figure 17

CLASS C RF AMPLIFIER

The actual output wave in Figure 17 is not the expected clipped wave which is characteristic of Class C RF amplifier circuits. The flywheel effect of the tank produces a damped sine wave output signal for each current pulse from the transistor. In Class C RF amplifier circuits, the tank receives the current pulse as shown in Figure 18.

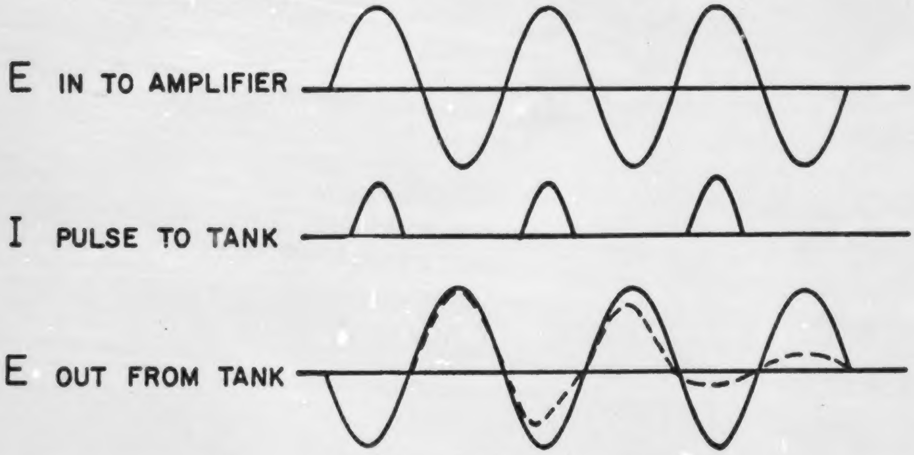

E IN TO AMPLIFIER
I PULSE TO TANK
E OUT FROM TANK

Figure 18

TANK OUTPUT FROM CLASS C AMPLIFIER OPERATION

The repeated current pulses change the damped output wave (shown by the dotted line) to resemble the reasonably good sine-wave (shown by the solid line). The flywheel effect is often used in Class AB, B, and C RF/IF amplifiers to provide a non-distorted sine wave output.

Amplifier efficiency is inversely related to the amount of operating power, and therefore, the amount of operating current. Class C amplifiers are the most efficient, and are used in applications which require large amounts of output power such as the final output amplifier of a ratio transmitter.

One method to test an amplifier's frequency response is to inject each frequency value from a standard signal generator into an amplifier, and then graph each output signal as displayed on an oscilloscope. A more efficient and accurate test method is to use a sweep frequency generator as input to the amplifier, and then directly observe the frequency response curve output on the oscilloscope. The sweep frequency generator produces a variable FM signal that sweeps back and forth over a section of the frequency spectrum.

Figure 19 shows a typical sweep frequency generator/oscilloscope set-up.

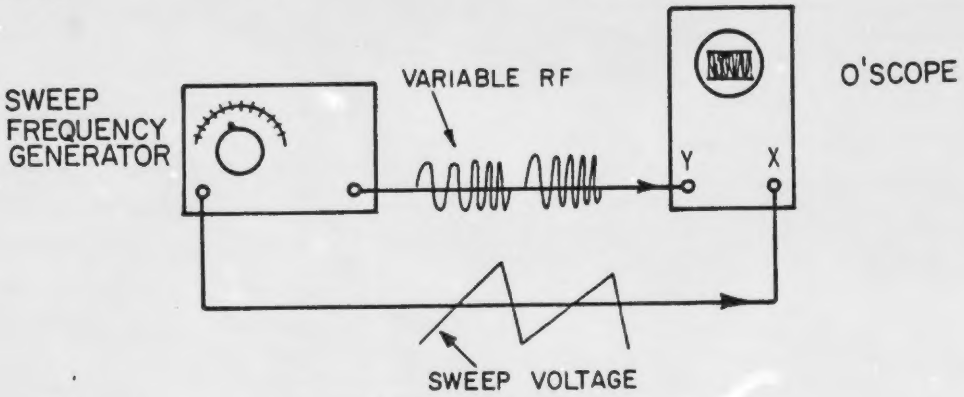


Figure 19

FREQUENCY SWEEP

The variable frequency signals from the generator are fed to the vertical input (Y) terminal of the oscilloscope. The CRT produces a rectangular display which is a combination of the sine waves from the input frequencies, and is often called a "frequency sweep". The generator also produces a horizontal sweep sawtooth wave output that is synchronized with the variable frequency output signal. The horizontal sweep output is connected to the X terminal of the oscilloscope. Since the oscilloscope inputs are synchronized, the CRT display is based on frequency and not on time.

A typical CRT display is shown in Figure 20.

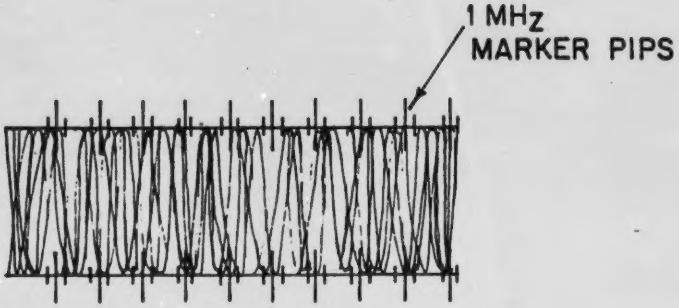

1 MHz
MARKER PIPS

Figure 20

FREQUENCY SWEEP WITH MARKERS

In the figure, the frequency marker pips show a sweep of 5 MHz on either side of an Fo of 5 MHz.

Figure 21 shows a typical sweep frequency generator test set-up.

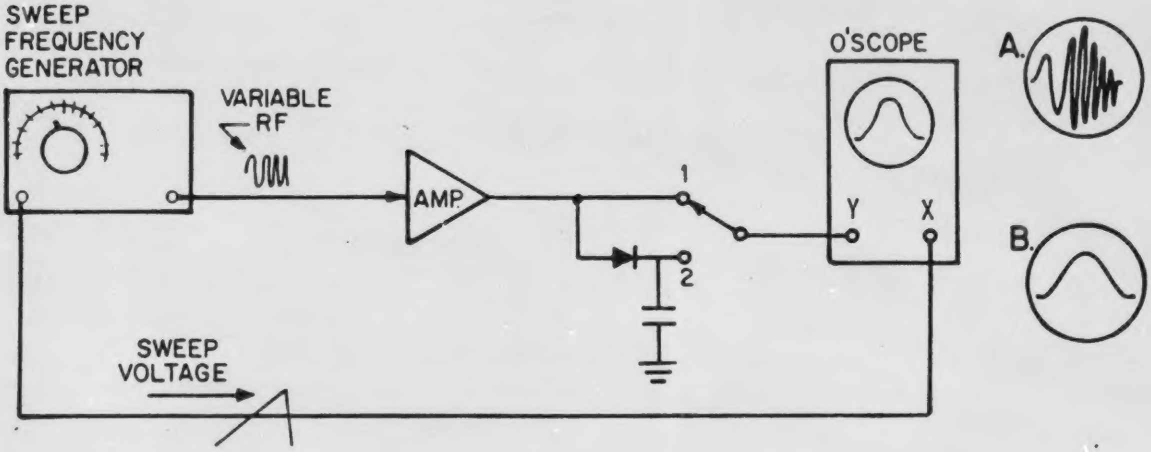

SWEEP FREQUENCY GENERATOR
VARIABLE RF
AMP.
1
2
O'SCOPE
Y
X
A.
B.
SWEEP VOLTAGE

Figure 21

SWEEP FREQUENCY GENERATOR METHOD

In switch position #1, the CRT displays insert A. In switch position #2, the rectifier-filter demodulator converts the CRT display to the frequency response curve in insert B.

You will have the opportunity to use the sweep frequency generator in the job program for this lesson. With this device, you will measure the frequency response of an RF amplifier in the NIDA trainer.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, YOU MAY TAKE THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 2

RF Amplifiers

TERMINAL OBJECTIVE(S):

31.2.53 When the student completes this lesson (s)he will be able to IDENTIFY the component functions and operating characteristics of RF amplifier circuits, including types of input and output transformer coupling, factors affecting and affected by Q in resonant circuits, response characteristics of different classes of amplifier operation, and one method for testing the frequency response of an amplifier, by selecting statements from a choice of four. 100% accuracy is required.

ENABLING OBJECTIVE(S):

When the student completes this lesson, (s)he will be able to:

31.2.53.1 IDENTIFY the components which accomplish tuning in a tuned, transformer-coupled RF amplifier circuit, given a schematic diagram, by selecting the correct component(s) from a set of four choices. 100% accuracy is required.

31.2.53.2 IDENTIFY the type of tuning (single, ganged, capacitive, inductive) used in a tuned, transformer-coupled RF amplifier circuit, given a schematic diagram, by selecting to correct type from a choice of four. 100% accuracy is required.

31.2.53.3 IDENTIFY or CALCULATE the effect of changes in inductive reactance, capacitive reactance, or resistance on the Q of a coil or tank circuit, by selecting the correct statement or value from a choice of four. 100% accuracy is required.

31.2.53.4 IDENTIFY or CALCULATE the effect of changes in Q on the bandwidth of a tank circuit, by selecting the correct statement or value from a choice of four. 100% accuracy is required.

31.2.53.5 IDENTIFY the effect of loading on the Q of a tank circuit by selecting the correct statement from a choice of four. 100% accuracy is required.

31.2.53.6 IDENTIFY the function of components and circuit operation (including neutralization of oscillation) in a tuned RF amplifier circuit by selecting the correct statement from a choice of four. 100% accuracy is required.

31.2.53.7 IDENTIFY the conduction time, operation, output waveforms, and relative efficiency of class A, B, AB, and C amplifiers by selecting the correct amplifier class, waveform, or statement from a choice of four. 100% accuracy is required.

31.2.53.8 IDENTIFY the effect of adding tuned tanks to transistor outputs (flywheel effect) on class AB, B, and C RF amplifier circuits by selecting the correct statement form a choice of four. 100% accuracy is required.

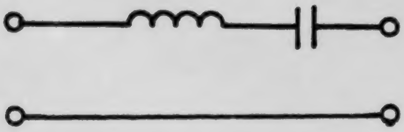
31.2.53.9 IDENTIFY the sweep frequency generator method of testing the frequency response of an amplifier by selecting the correct statement from a choice of four. 100% accuracy is required.

PROGRESS CHECK
LESSON 2

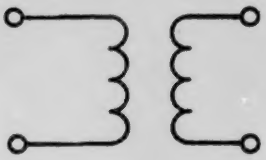
RF Amplifiers

1. From the diagrams below, select the two parallel resonant coupling circuits.

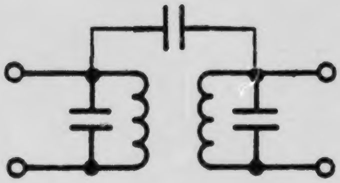
A.



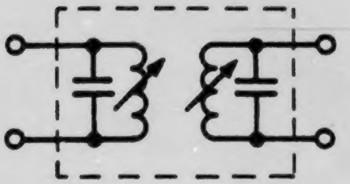
B.



C.

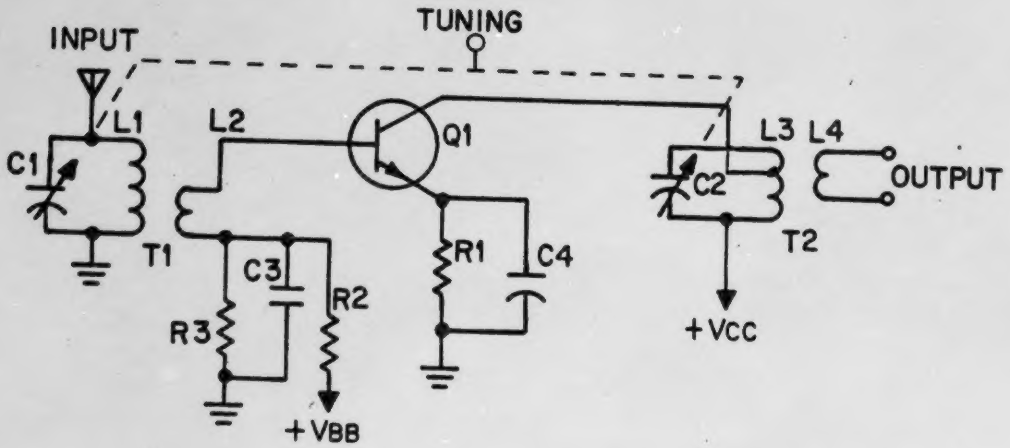


D.



1. A, B
2. B, C
3. C, D
4. D, B

USE THE DIAGRAM BELOW TO ANSWER QUESTIONS 2 AND 3.


TUNING
INPUT
L1
C1
L2
T1
Q1
C3
R3
R2
+VBB
R1
C4
C2
L3 L4
OUTPUT
T2
+VCC

2. In this amplifier, tuning is done in
   1. the input section only
   2. the output section only
   3. the conversion section only
   4. both input and output sections

3. This amplifier has ______________ tuning.
   1. single inductive
   2. single capacitive
   3. ganged inductive
   4. ganged capacitive

4. The Q of tank A is 10, and the Q of tank B is 20. Both tanks have the same Fo. Tank A has a __________ bandwidth and ____________ selectivity than tank B.
   1. narrower, less
   2. narrower, greater
   3. wider, less
   4. wider, greater

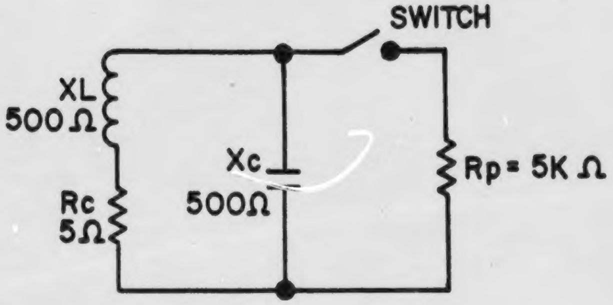
5. Both coil A and coil B have the same XL. Coil A is wound with smaller diameter wire than coil B. The Q of coil A is

   1. higher than the Q of coil B
   2. lower than the Q of coil B
   3. the same as the Q of coil B

6. Swamping resistors are placed across tank circuits in order to

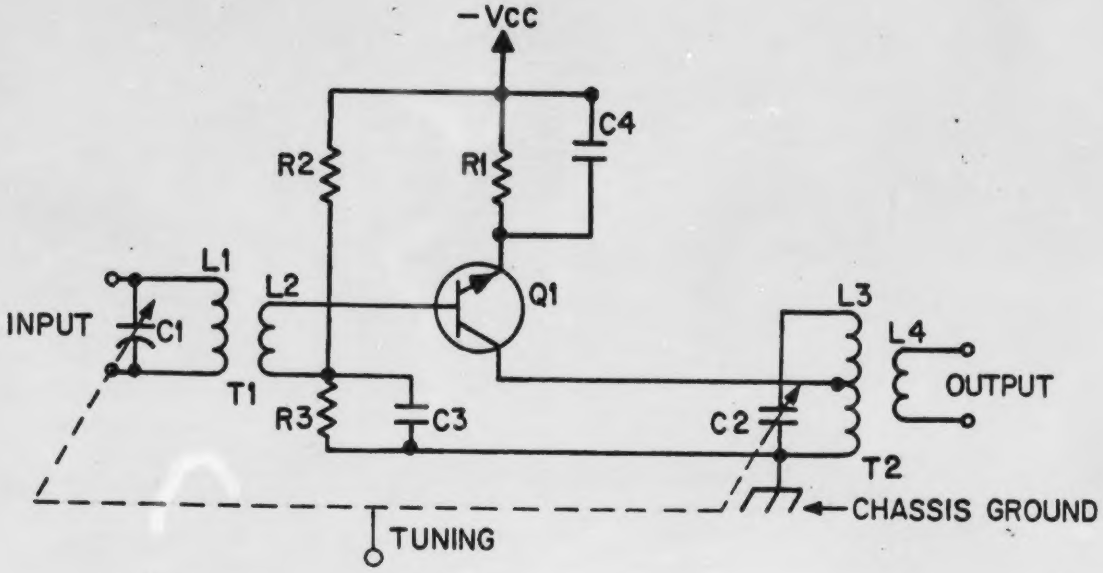
   1. increase the selectivity of the amplifier
   2. increase the Q of the tank
   3. increase the gain of the amplifier
   4. widen the bandwidth of the tank

USE THE DIAGRAM BELOW TO ANSWER QUESTION 7.



7. The Q of the resonant circuit with the switch closed has a value of ____________________.

USE THE DIAGRAM BELOW OF AN RF AMPLIFIER CIRCUIT TO ANSWER QUESTION 8.


-VCC
C4
R2
R1
L1
L2
Q1
L3
INPUT
C1
L4
OUTPUT
T1
R3
C3
C2
T2
CHASSIS GROUND
TUNING

8. An impedance match between Q1 and the output coupling network is performed by which component?

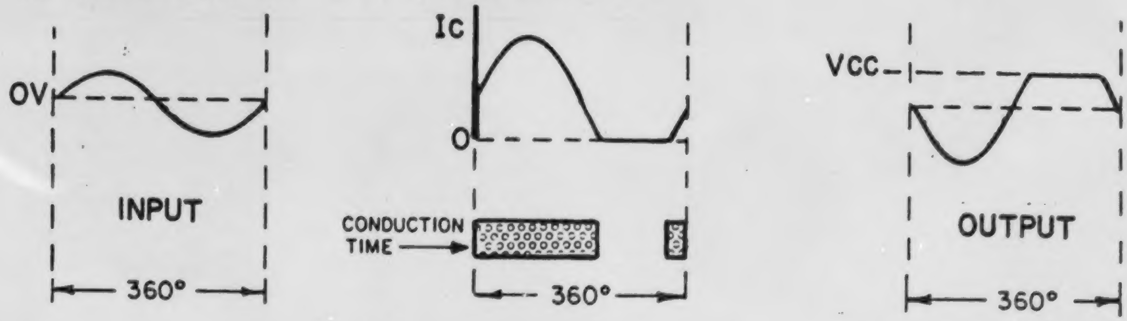
   1. C2
   2. L3
   3. L4
   4. Vcc

9. The purpose of neutralization components in RF amplifiers is to prevent

   1. stray reactances
   2. oscillation
   3. internal feedback
   4. external feedback

10. The transistor conducts for half the signal input cycle in Class __________ amplifiers.

USE THE DIAGRAM BELOW TO ANSWER QUESTION 11.



11. The diagram shows the output signal waveform for Class ____________ amplifiers.

12. The least efficient amplifier class of operation is Class ____________.

13. Non-distorted sine wave outputs in Class AB, B, and C amplifiers are provided by

    1. increasing the pulse rate through the transistors
    2. matching impedance between transistor inputs and outputs
    3. adding RC components to transistor outputs
    4. using tuned tanks in transistor amplfiers

14. The oscilloscope CRT display from a sweep frequency generator is based on

    1. a single frequency
    2. variable amplitudes
    3. variable frequencies
    4. variable time

15. In order to directly observe the frequency response curve for a test amplifier, the amplifier input comes from a

    1. sweep frequency generator
    2. standard RF signal generator
    3. standard oscilloscope
    4. VOM

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE LESSON TEST. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

INFORMATION SHEET
LESSON 2

Telonic 1232A Sweep Generator

The sweep generator is a versatile piece of test equipment that can be used to align receivers or to check bandwidth and frequency response of electronic circuits.

The sweep generator is a type of signal generator. When the signal generators you used previously were set to a frequency, they produced only that frequency. A sweep generator produces a signal that varies (sweeps) from a frequency below the center frequency to a frequency above the center frequency. This is usually stated as the center frequency plus or minus some number of Hertz; for example, 10.7 MHz ± 75 kHz. This means that the sweep frequency generator is capable of producing an output signal from 75 kHz below 10.7 MHz (10.625 MHz) to 75 kHz above 10.7 MHz (10.775 MHz). These frequencies therefore could be used for alignment of IF amplifiers in commercial FM receivers.

The sweep generator produces an output which has a flat response curve across a very broad band of frequencies. That is, the signal amplitude stays the same throughout its sweep range.

When used with an oscilloscope, the output of the sweep generator is visually displayed for alignment or bandwidth and frequency response measurement of the device under test.

Markers are added to the display to aid in determining center frequency, bandwidth, and frequency response.

Markers are signals injected by the sweep generator to provide a reference for signal location.

The sweep generator produces a horizontal reference voltage which when applied to the horizontal input of the oscilloscope, is equal to the amount of variation above and below the center frequency.

The signal as applied to the vertical input will give an indication as to the gain of the unit under test with reference markers superimposed.

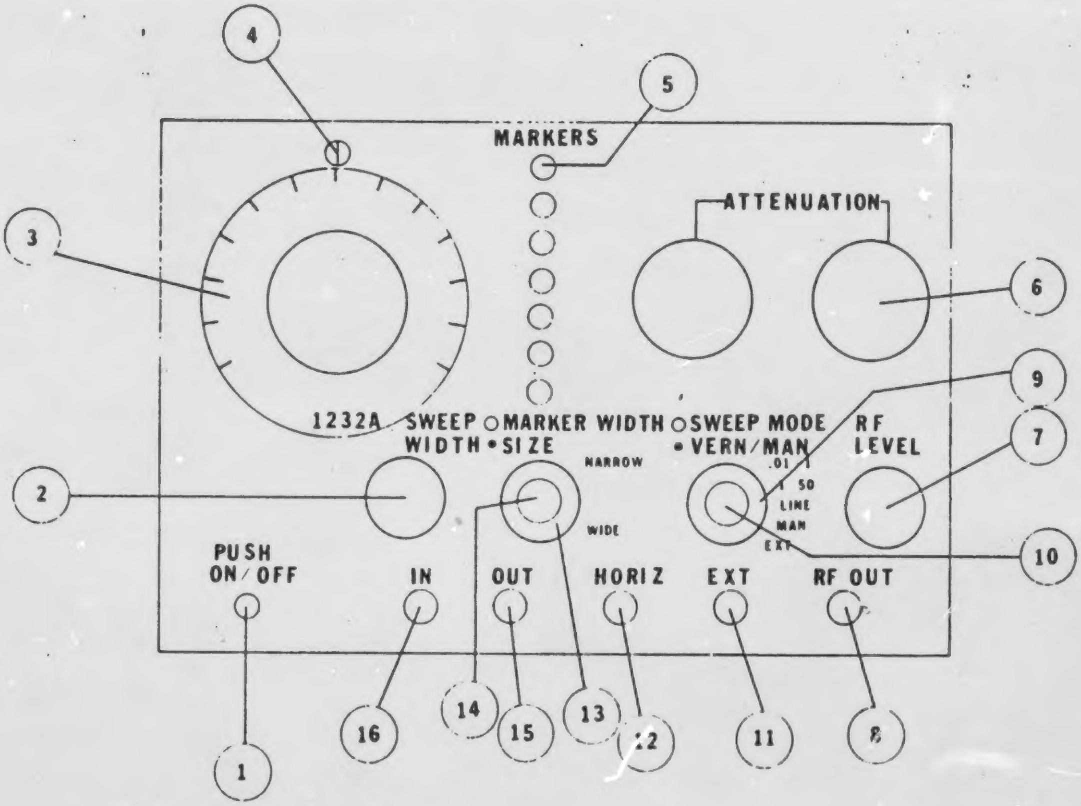

4
5
MARKERS
ATTENUATION
3
6
9
7
1232A
SWEEP WIDTH
○MARKER WIDTH
• SIZE
NARROW
WIDE
○SWEEP MODE
• VERN/MAN
.01
1
50
LINE
MAN
EXT
RF LEVEL
2
10
PUSH ON/OFF
IN
OUT
HORIZ
EXT
RF OUT
14
13
16
15
12
11
8
1

Figure 1

MODEL 1232A FRONT PANEL CONTROLS AND CONNECTORS

FUNCTION OF CONTROLS, SWITCHES AND CONNECTORS

Refer to Figure 1 for the below listed controls and connectors.

1. POWER SWITCH (1) provides on/off control of AC power.
2. SWEEP WIDTH (2) provides continuous variation in sweep width from 100 kHz to 120 MHz. The variation is above and below the center frequency.
3. CENTER FREQUENCY DIAL (3) determines the center frequency of the swept RF output.
4. POWER INDICATOR AND DIAL POINTER (4) illuminates when instrument is turned on.

5. MARKERS ON/OFF (5) provides on/off control of individual markers.

6. ATTENUATORS (6) provides coarse and fine attenuation of the RF output.

7. RF LEVEL (7) provides 3 dB of RF output level variation. This will give you the 70.7% of the output signal to determine the half-power points.

8. RF OUT (8) type BNC connector provides swept RF output.

9. SWEEP MODE (9) selects various sweep rates and modes.

10. VERN/MAN (10) varies the sweep rate of the output signal.

11. EXT INPUT (11) type BNC connector provides an input for external control of sweep.

12. HORIZ OUTPUT (12) type BNC connector provides a sweep voltage (horizontal reference voltage) to the horizontal input of an oscilloscope.

13. MARKER WIDTH (13) selects between two marker widths

14 MARKER SIZE (14) varies the amplitude of the markers.

15. MARKER ADDER OUT (15) type BNC connector provides detected response with markers superimposed to vertical input of an oscilloscope.

16. MARKER ADDER IN (16) type BNC connector. Provides an input for the detected response for superimposing the markers

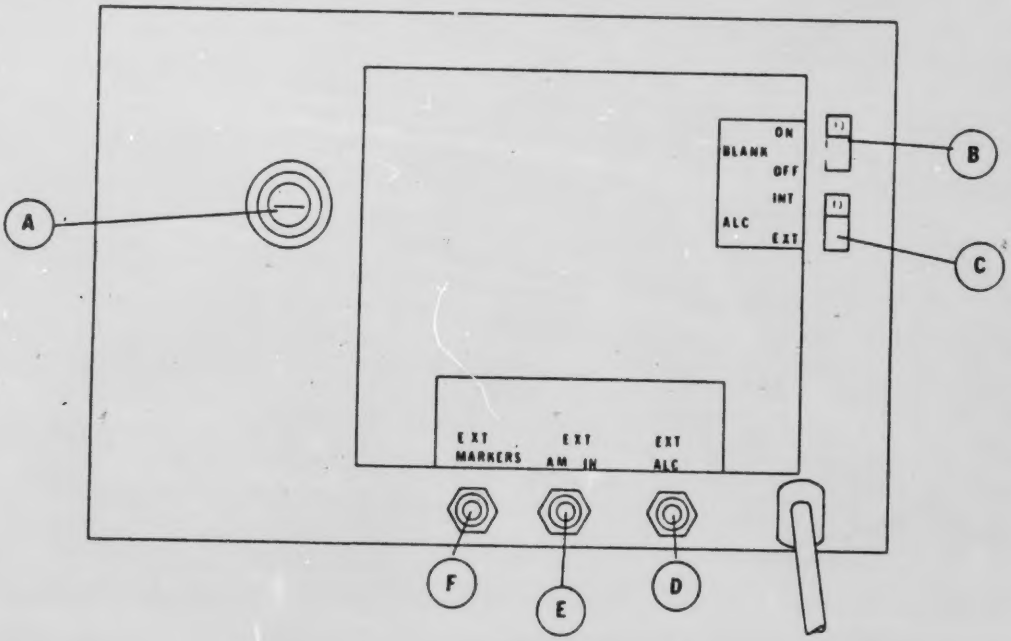


Figure 2

MODEL 1232A REAR PANEL CONTROLS AND CONNECTORS

Refer to Figure 2 for the below listed controls and connectors.

1. Fuseholder (A) contains power line fuse (1 amp).
2. BLANKING ON/OFF (B) switch retrace blanking "on" or "off." (permits showing or eliminating sweep returning to start of trace).
3. ALC INT/EXT (C) Selects between the internal monitor or an external monitor. (ALC or automatic level control, keeps the RF output at a constant level)
4. EXT ALC INPUT (D) type BNC connector provides input for an external monitor. The monitor is an RF detector used to sample the output.
5. AM INPUT (E) type BNC connector provides input for AM modulation of the RF output. (will not be used at this time)
6. EXT MARKER INPUT (F) type BNC connector. Provides an input at 50 Ω (ohms) from an external source which is used to generate a marker at the source frequency.

JOB PROGRAM
FOR
LESSON 2

Sweep Generators and RF Amplifiers

INTRODUCTION

This job program is designed to familiarize you with the operation of the Telonic Model 1232A Sweep Generator and the uses to which it can be applied in the alignment of receivers and in checking bandwidth and frequency response in electronic circuits. All voltages and resistances measured should be within +/- 20% tolerance with those given on the answer sheet to the job program.

TERMINAL OBJECTIVE(S):

31.2.53 When the student completes this lesson (s)he will be able to IDENTIFY the component functions and operationg characteristics of RF amplifier circuits, including types of input and output transformer coupling, factors affecting and affected by Q in resonant circuits, response characteristics of different classes of amplifier operation, and one method for testing the frequency response of an amplifier, by selecting statements from a choice of four. 100% accuracy is required.

ENABLING OBJECTIVES:

When the student completes this lesson (s)he will be able to:

31.2.53.10 MEASURE and COMPARE frequency response curve characteristics of an RF amplifier, given a training device, circuit boards, test equipment and proper tools, schematic diagrams, and a job program containing references for comparison. Recorded data must be within limits stated in the job program.

SAFETY PRECAUTIONS

Observe all standard safety precautions. Beware of all exposed connections. An energized circuit may have dangerous voltages present.

EQUIPMENT REQUIRED:

1. Telonic 1232A Sweep Generator
2. Dual Trace Oscilloscope.
3. RF Detector Model 8571
4. NIDA 205 Transceiver Trainer.
5. BNC-BNC cables (2 long).
6. BNC-BNC cable (2 short).

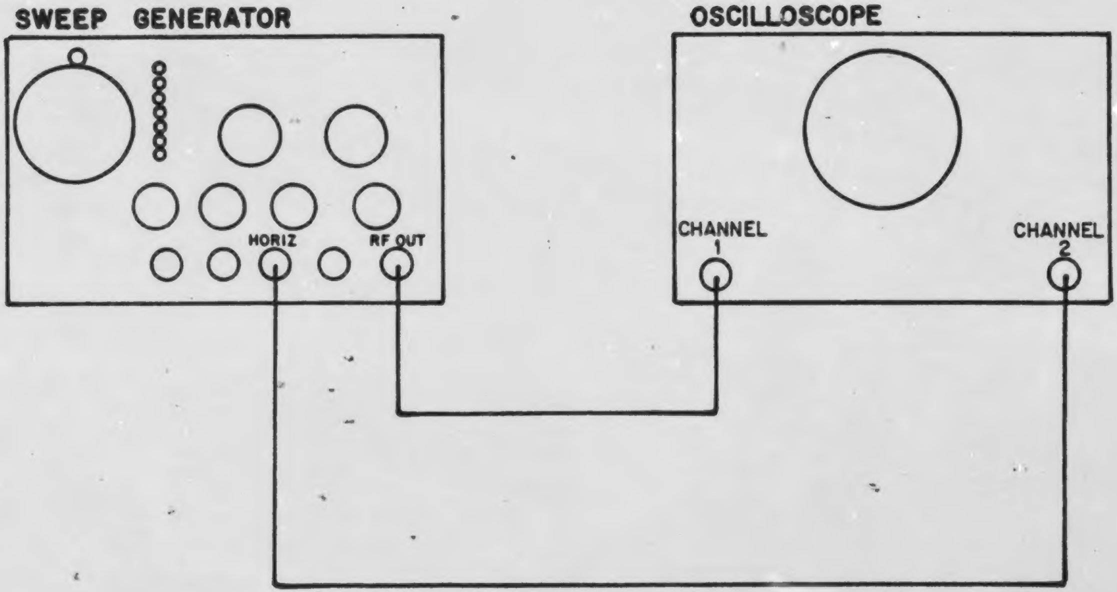

SWEEP GENERATOR
HORIZ
RF OUT
OSCILLOSCOPE
CHANNEL 1
CHANNEL 2

Figure 1

PROCEDURES:

1. Connect the Sweep Generator as shown in Figure 1.
2. Set the controls on the Sweep Generator as follows:
    a. Sweep width control fully CCW.
    b. Sweep mode control to "EXT/CW".
    c. VERN/MAN control to mid-range.
    d. RF level control to mid-range.
    e. Attenuation controls to "0".
    f. Center frequency dial to "0".
    g. Blanking on/off to "off" (Back of Sweep Generator).
    h. Turn all marker switches to "off" position.
3. Set the oscilloscope to the X-Y mode (all display mode switches out).
    a. Set the channel 1 Volts/Div control to "2".
    b. Set the channel 2 Volts/Div control to "2".
    c. Set the channel 1 and channel 2 mode switches to the "out" position.
    d. Set triggering source switch to "EXT".
4. Turn on the sweep generator and the oscilloscope. Allow sufficient time for the equipment to warm up.
5. You should see a vertical line on the oscilloscope. Using the chan 2 horizontal position control, center the line on the scope. Manipulate the following controls on the oscilloscope so you can see that they have no effect on the presentation.
    a. Time/Div controls.
    b. Triggering controls.
    c. Horizontal position control.

NOTE: Now you can see that the sweep generator controls the presentation on the scope. There is an RF output from the sweep generator, but no horizontal output at this time, indicating there is no sweep voltage being applied to the horizontal deflection plates of the oscilloscope.

6. To prove that there is a frequency from the sweep generator, remove the BNC connector from the channel 1 input to the scope.

   a. What happened to the vertical line?________________.

   b. Reconnect the BNC connector to channel 1 of the scope.

7. Set the sweep mode switch on the sweep generator to the ".01-1" position. Notice that the trace on the scope starts to sweep from a frequency below to a frequency above the frequency observed in step 5, indicating that there is a sweep voltage from the sweep generator horizontal output jack.

8. To prove this, remove the BNC connector from the channel 2 input to the oscilloscope.

   a. What happened to the sweep voltage?________________.

   b. Reconnect the BNC connector to channel 2 of the scope.

9. Set the sweep mode control to the "1-50" position. Notice that the sweep speed increased.

10. Turn the sweep width control to mid-range. You should notice an increase in amplitude over a small range of the presentation.

11. Turn the center frequency dial until the center of this change in amplitude is exactly in the center of the scope.

12. Turn the sweep width control until the left and right side of the display drops to zero.

    a. What happened to the amount of frequencies being swept by the sweep generator?_____________.

13. Set the sweep mode control to the ".01-1" position. Notice that the waveform, if plotted, is exactly the same as the waveform in step 12.

14. Set the VERN/MAN control fully CCW.

15. Turn the VERN/MAN control slightly CW. Notice that the center frequency starts to sweep.

16. Turn the VERN/MAN control to mid-range.

    a. What happened to the rate (speed) at which the frequencies are being swept?________________.

NOTE: You should have noticed in the foregoing part of the job program that the frequency dial was set at zero(0) and that moving the sweep width control caused the frequency to change to the right and to the left by a certain amount of frequencies. Increasing the sweep width control in a CW direction further, caused the amount of frequencies on either side of zero(0) to increase. Rotating the VERN/MAN control increased the rate (speed) at which the frequencies were being swept.

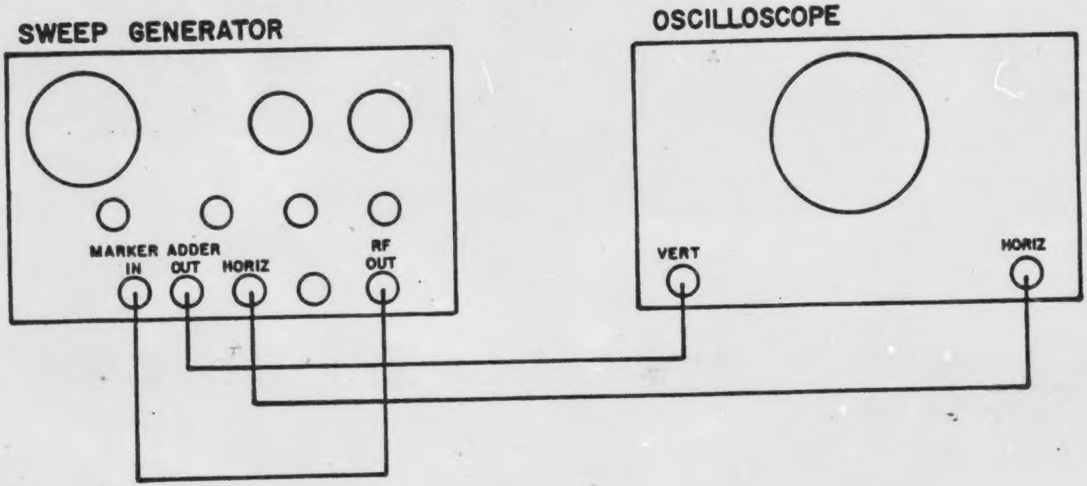


Figure 2

17. Connect the equipment as shown in Figure 2.

18. Set the controls on the sweep generator as follows:

    a. Turn the seven markers switches to the "off" position.

    b. Set the sweep width control to mid-range.

    c. Set the marker width control to "wide"

    d. Set sweep mode control to "1-50".

    e. Set VERN/MAN control to mid-range.

    f. Set the center frequency dial to "0".

    g. Set the marker size to mid-range. During the job program you may manipulate this control to your own individual eye comfort and to insure accuracy.

19. There should be a marker in the center of the scope. If the marker is not exactly centered on the scope and your sweep is centered, adjust your center frequency dial until the marker is centered on the scope. This is the zero (0) Hz marker. This will be used as a reference to locate the frequency that you want as the center frequency.

20. Set the center frequency dial to "5". The zero Hz marker should move to the left side of the scope.

21. On the sweep generator turn the third markers switch from the top to "on". This is the 10 MHz markers switch. The first 10 MHz marker should appear on the right side of the scope but not at the end of the sweep. The RF output is being swept from 0 HZ to 10 MHZ.

22. Adjust the center frequency dial until the 10 MHz marker appears 2 cm to the right of the vertical center line.

23. Turn "off" the 10 MHz markers switch. Turn "on" the second marker switch from the top on the sweep generator. These are the 1 MHz markers. Count them. There should be 9 markers between 0 Hz and the 10 MHz point.

24. From 0 Hz count the number of markers to the center of the scope.

    a. How many markers are there?____________________.

25. From the point that you established as 10 MHz, count the markers to the center of the scope.

    a. How many markers are there?____________________.

    b. What is the center frequency?__________________.

    c. What is the center frequency dial on the sweep generator set to?______________________.

    d. Do b and c above correspond?___________yes/no.

    e. Should they correspond?_________yes/no.

26. Set the center frequency dial to "0".

27. Rotate the sweep width control on the sweep generator CCW until the "0" Hz marker is on the left side of the scope and the center of the first 1 MHz marker appears on the right. Sweep length is now 1 MHz. The output is now being swept from 0 Hz to 1 MHz. Much can be determined from this. THINK.

    a. What is the center frequency?___________________.

    b. What is the frequency response?________________.

c. What is the bandwidth?_______________.

d. Turn off the 1 MHz markers.

28. Now let us go through the steps necessary to set the sweep generator to a specific center or resonant frequency. For this example let us choose 97.6 MHz.

a. Set the sweep width control to mid-range.

b. Set the center frequency dial to "0".

c. Position the 0 Hz marker at the center of the scope using the center frequency dial.

d. Turn on the 10 MHz marker switch. A 10 MHz marker should appear to the right and to the left of your center frequency 0 Hz marker. If it does not, turn the sweep width control CW until it does.

e. Turn the center frequency dial to 10. The first 10 MHz marker should appear at the center of the scope.

f. Turn the center frequency dial to 20. The second 10 MHz marker should appear at the center of the scope.

g. Turn the center frequency dial to 30. The third 10 MHz marker should appear at the center of the scope.

NOTE: The frequency dial may be slightly off from the actual display on the scope. Do not worry about it. The presentation on the oscilloscope is your true indication.

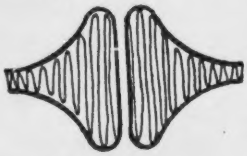
h. Turn the center frequency dial to 40. The fourth 10 MHz marker should appear at the center of the scope. You are now receiving 40 MHz from the sweep generator. Use the above procedure until you observe the 90 MHz marker at the center of the scope.

i. Turn off the 10 MHz markers and turn on the 1 MHz markers. The center marker is still 90 MHz.

j. Turn the center frequency dial and count 91, 92, 93, 94, 95, 96, 97. You now have 97 MHz centered on the oscilloscope which you are receiving from the sweep generator.

k. Turn off the 1 MHz markers. The top markers switch produces .1 MHz (100 kHz) markers. Turn it on.

l. Turn the sweep width control CCW until a signal appears looking like this. Center the display on the scope using the center frequency dial.



The very center of this waveform is 97 MHz.

m. Very gently turn the center frequency dial while counting 97.1, 97.2, 97.3, 97.4, 97.5, 97.6. If you do not do this gently you will have to go through the entire procedure again. The sweep generator is now producing 97.6 MHz.

n. Turn the sweep width control to mid-range.

NOTE: Although the frequency dial may be off, and it often is, even in test equipment in the field, the sweep generator is producing the correct frequency and the marker pips on the oscilloscope is your proof that it is.

NOTE: If you do not understand the above, select your own frequencies in the MHz range and practice setting up the sweep generator to increase your proficiency before proceeding further in this job program. The following part of the job program requires the addition of an RF detector Model 8571 and the NIDA 205 Transceiver Trainer.

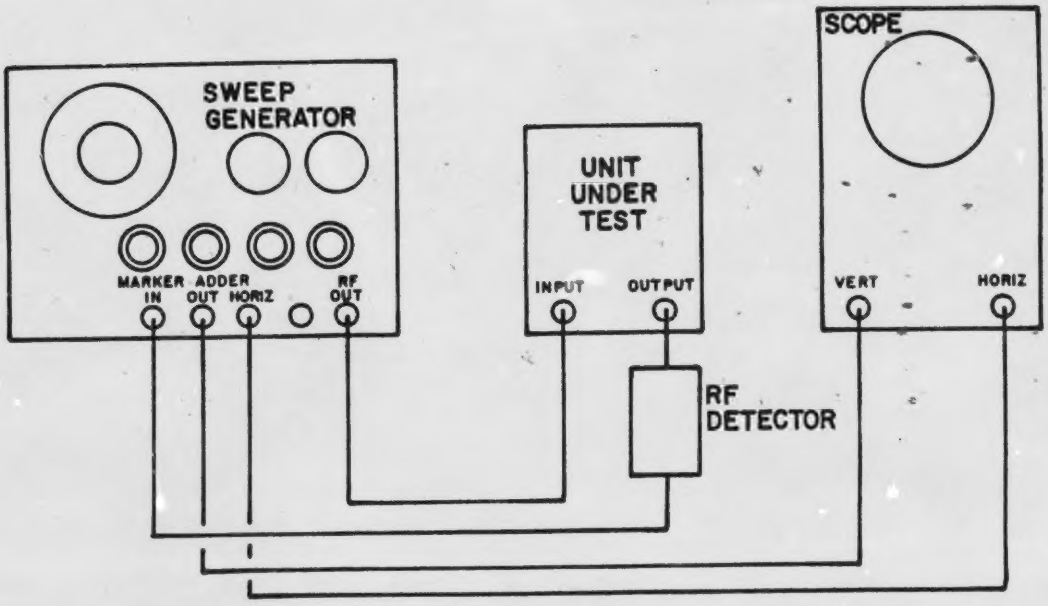


Figure 3

29. Connect the equipment as shown in Figure 3.

30. Set the channel 1 Volts/Div control on the oscilloscope to 1.

31. Make the following adjustments on the NIDA 205 Transceiver.
(Refer to schematic - end of this lesson)
    a. Remove the bottom cover
    b. Plug in and energize the NIDA 205 Transceiver
    c. Using the fine frequency control, set up the NIDA 205 Transceiver to 97.6 MHz approximately.

32. Observing the NIDA 205 Transceiver you will notice the 3 tuning capacitors and the trimmer capacitors with 5 alignment screws with eyelets attached to each trimmer capacitor. You are going to use the eyelet closest to the front of the Transceiver for your observations. This is the input tank to the RF amplifier. Insert the RF detector probe into this eyelet.

33. Turn the fine frequency control on the NIDA 205 Transceiver until a frequency response curve appears on the scope. Center this response curve on the scope.

CAUTION:

DO NOT leave your hands anywhere near the RF detector probe as hand capacitance will affect your reading. Run the connecting cables behind the Transceiver.

34. Prove this to yourself by holding the probe first with one hand then with two hands while noticing the changes in amplitude and frequency on the oscilloscope.

35. Turn all marker switches to the off position.

36. Calculate the peak amplitude of the scope waveform________________.
Calculate what the amplitude should be at the .707 power points________.

37. Turn the RF level control fully CCW. This is exactly 3dB down from peak or the half power points. Calculate the amplitude of the waveform on the oscilloscope_____________.
    a. Does the amplitude in step 37 correspond to the amplitude in the second part of step 36?__________yes/no.
    b. Should they correspond?__________yes/no.

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NOTE: You have obtained some very important information. You found the resonant frequency of the input tank and the amplitude of this frequency at its Fo and also at the half power points. Now you are ready for bandwidth and frequency response measurements.

38. Using the vertical position control on the oscilloscope, set the peak amplitude of the waveform exactly on the center horizontal reference line. This will be your reference point for the following measurements.

39. Turn the RF level control fully CW.

40. Turn on the 1 MHz markers.

41. Using the sweep frequency dial, center the display on the scope.

42. Turn the sweep width control to show five 1 MHz markers. Using the sweep frequency dial, again center the display on the scope, if necessary.

43. Turn off the 1 MHz markers.

44. Turn on the .1 MHz markers.

45. Turn the sweep width control until a .1 MHz marker corresponds with the reference level.

46. From the center of the oscilloscope, count the number of .1 MHz markers to the reference level.

    a. How many markers are there?_________________.

    b. What is the frequency response of the input tank of the RF amplifier?_________________.

    c. What is the bandwidth?_________________.

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON TEST. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

SCHEMATIC DIAGRAM

RF AMPLIFIER/FREQUENCY CONVERTER

PC 205-7

P.P. 161, 162

SUMMARY
LESSON 3

IF Amplifiers

IF amplifiers are commonly found in both receivers and transmitters. IF amplifiers provide the required signal gain and selectivity in superheterodyne receivers such as radio, television, and radar.

An IF amplifier is basically a tuned, high gain, fixed frequency RF amplifier with transformer coupling. Ideally, the IF amplifier will select and amplify with constant gain only the desired signal containing all the information needed for good signal reproduction. Therefore, the ideal IF amplifier should have the rectangular frequency response curve shown in Figure 1.

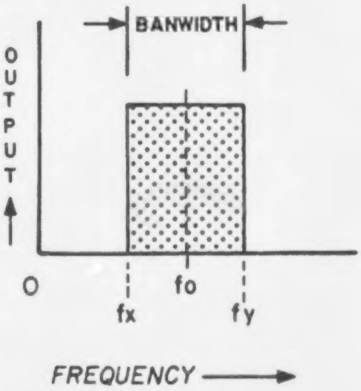

Figure 1

IDEAL IF RESPONSE CURVE

An actual IF amplifier with tuned-primary transformer coupling has a frequency response curve which more closely resembles Figure 2.

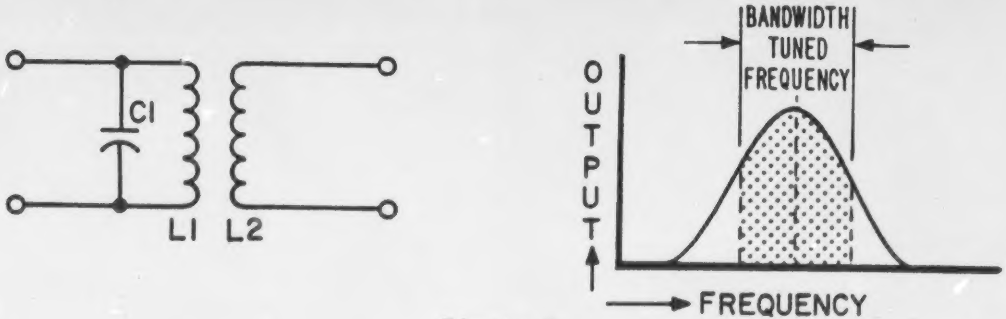

Figure 2

SINGLE TUNED TRANSFORMER COUPLING

There are ways to make the frequency response curve of an IF amplifier resemble the ideal curve and thus improve amplifier operation. One method is to tune all circuits in the signal path to the same frequency, or synchronous tune. A tuned circuit may be added to the secondary of the transformer coupling in Figure 2. If the two tuned tanks are synchronous tuned to the IF center frequency, the resulting frequency response curve is shown in Figure 3.

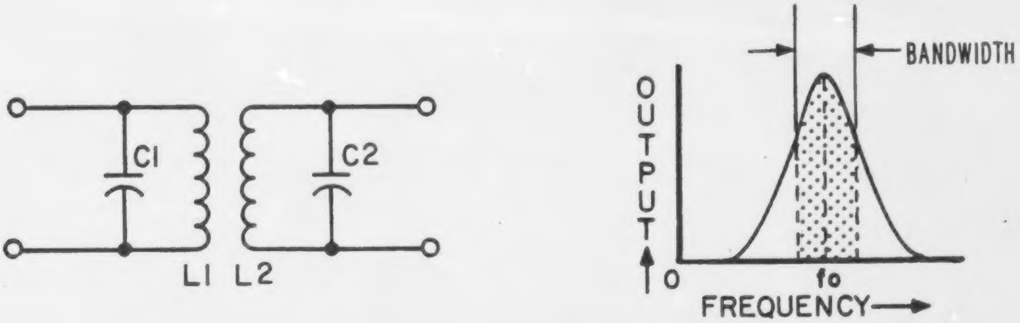

Figure 3

SYNCHRONOUS DOUBLE-TUNED TRANSFORMER COUPLING

In the figure, the bandwidth has become narrower and selectivity has increased.

Synchronous tuning may cause the bandwidth to become too narrow to properly amplify all of the desired signal. For example, television and radar signals require relatively broad bandwidth amplification.

One method to increase the bandwidth of an IF amplifier is to tune each tuned coupling circuit to a slightly different frequency, or stagger tune. The resulting frequency response curve for an amplifier with three stagger-tuned circuits is shown in Figure 4.

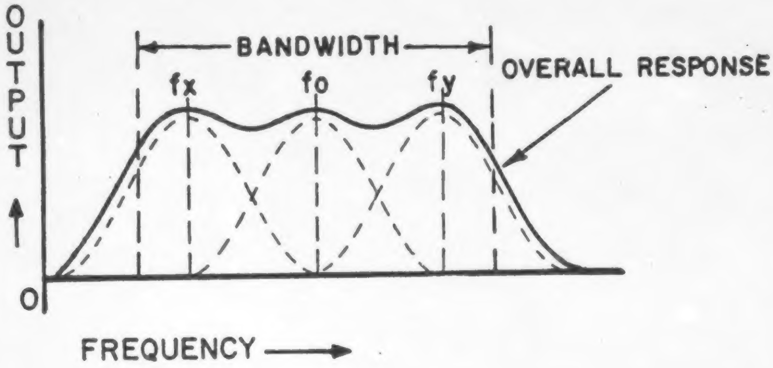

Figure 4

STAGGER-TUNED RESPONSE CURVE

You can see that stagger tuning resonant coupling circuits widens amplifier bandwidth.

Synchronous and stagger tuning can be applied to the operation of a typical common-emitter IF amplifier stage shown in Figure 5.

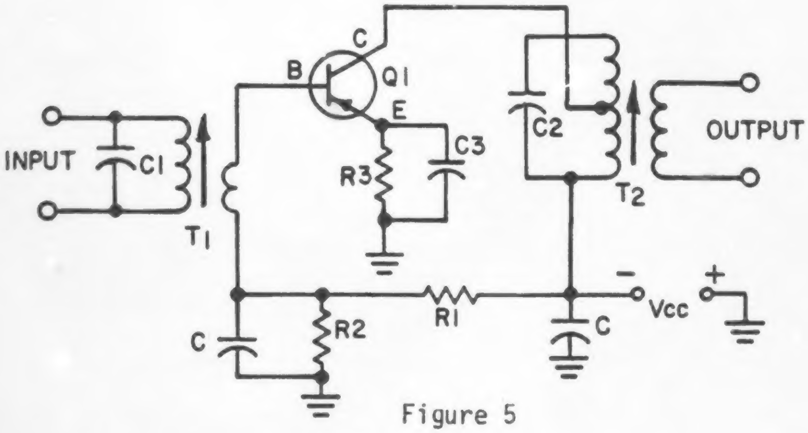

Figure 5

TYPICAL COMMON-EMITTER IF STAGE

This circuit contains two single-tuned interstage coupling transformers. T1 and T2 can be synchronous slug-tuned to provide a narrow bandwidth amplifier with good selectivity. T1 and T2 can also be stagger tuned to increase amplifier bandwidth. Proper tuning in a string of IF amplifiers will produce just about any gain and selectivity required in the receiver.

The NIDA trainer IF amplifier stage is shown in Figure 6.

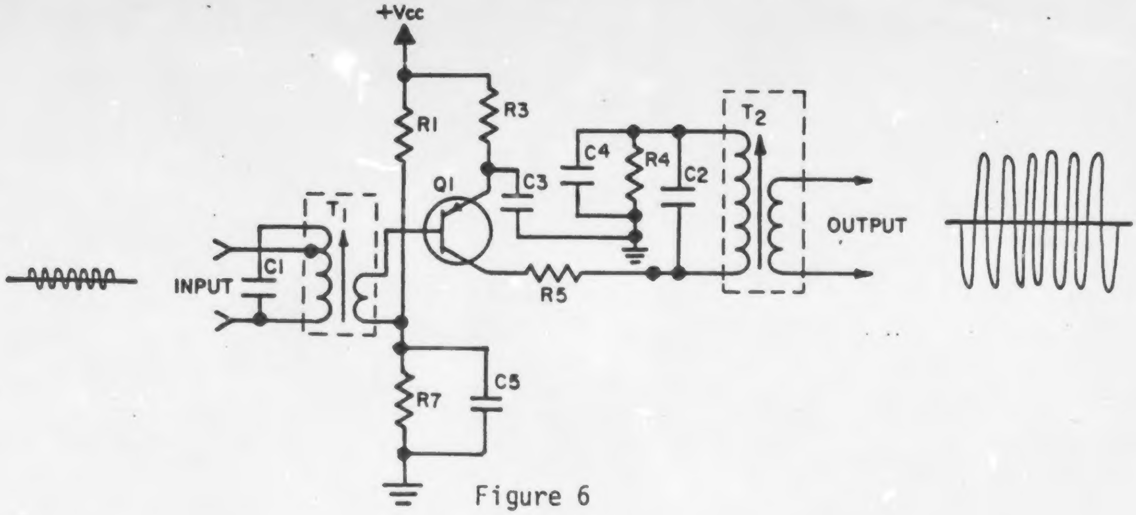

Figure 6

NIDA IF AMPLIFIER

The input signal is applied to coupling transformer T1. The tap on T1 provides an impedance match with the collector circuit in the previous stage. This type of transformer is often enclosed in an aluminum shield to prevent unwanted coupling to nearby wires and transformers. Inductive tuning is done by a tuning slug. The step-down secondary on T1 provides a low impedance match to the Q1 base circuit. R1 and R2 provide forward bias to Q1.

Decoupling capacitor C5 ensures all signal voltage is developed across the secondary of T1, and does not enter the power supply.

In the Q1 collector circuit, the output tank in coupling transformer T2 is tuned to the operating center frequency of 10.7 MHz. C4 and R4 are decoupling components which act to ensure that all signal voltage is developed across the tank, and does not enter the power source. R5 reduces the tendency for strong signals to forward bias the collector-base junction of Q1 which might cause oscillation.

IF amplifiers are usually cascaded to perform their function in a receiver or transmitter. As the number of cascaded amplifiers increases, the gain may become high enough to cause one or more amplifier stages to be overdriven. Severe signal distortion would result as the design capabilities of the circuit and power supply would be exceeded. Therefore, some type of gain control is needed.

The amount of forward bias on the transistor's base-emitter junction (V_{BE}) affects the static operating level of the transistor which, in turn, affects the amount of gain. The transistor produces a reasonably constant gain within a certain bias range called the linear operating region for the transistor. When the forward bias is significantly above or below the linear region, the transistor is operating in the non-linear operating regions. In these regions, the transistor produces lower gain and, with large signals, possible distortion.

The relationship between bias, conduction, and gain are found in the transistor characteristic curve in Figure 7.

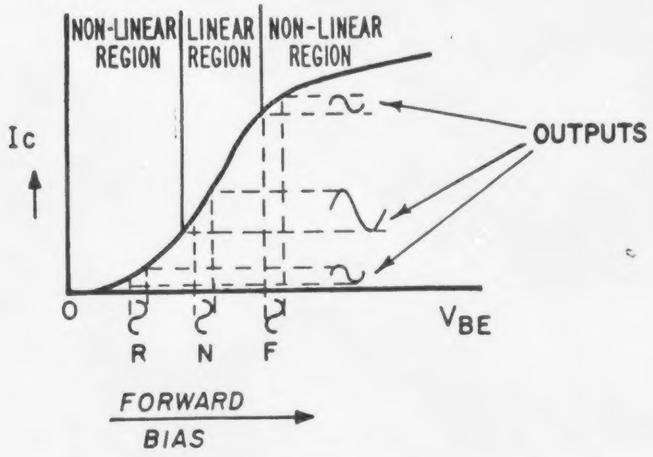

Figure 7

TRANSISTOR CHARACTERISTIC CURVE

The curve is used to determine the amount of gain related to bias and conduction levels for a given input signal. Figure 7 shows examples of three identical input signals applied to a transistor at bias levels within each of the regions. The amplitudes of the input signals are shown above the region labels. The difference in the resulting output amplitudes demonstrates that gain is reduced by applying forward bias either in the "R" region (reverse bias gain control) or in the "F" region (forward bias gain control). You should note that distortion in the non-linear regions is minimized with small signal levels.

A manual method of controlling transistor gain can be shown for the NIDA trainer IF amplifier stage in Figure 8.

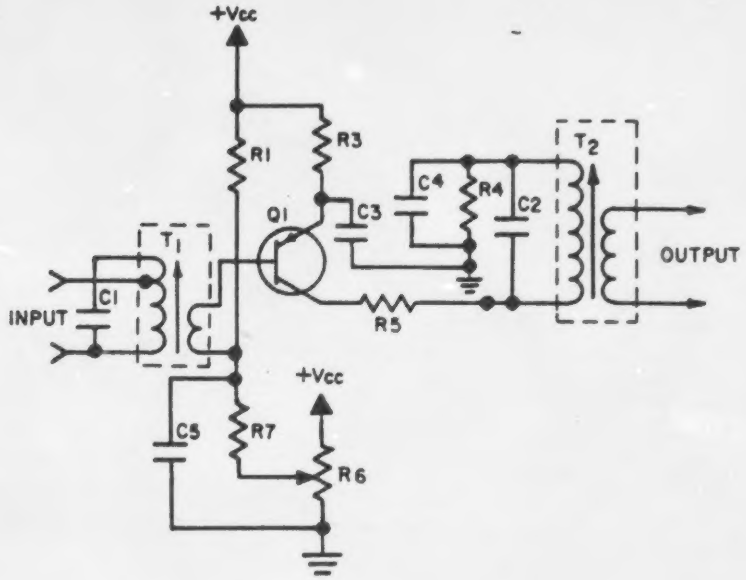
+Vcc
R1
R3
T2
C4
R4
C2
C3
Q1
T1
OUTPUT
C1
INPUT
R5
+Vcc
C5
R7
R6

Figure 8

MANUAL IF GAIN CONTROL

In the figure, forward bias is provided by R1, R2, and R6. As the arm of R6 is moved upward, a more positive voltage is placed on the base of Q1 which reduces the forward bias on Q1. If the arm of R6 is moved upward high enough, reverse bias gain control will result.

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An automatic gain control (AGC) circuit provides a more constant output from the audio or video equipment in which it is used. Figure 9 shows the addition of an AGC circuit to the IF amplifier stage in Figure 8.

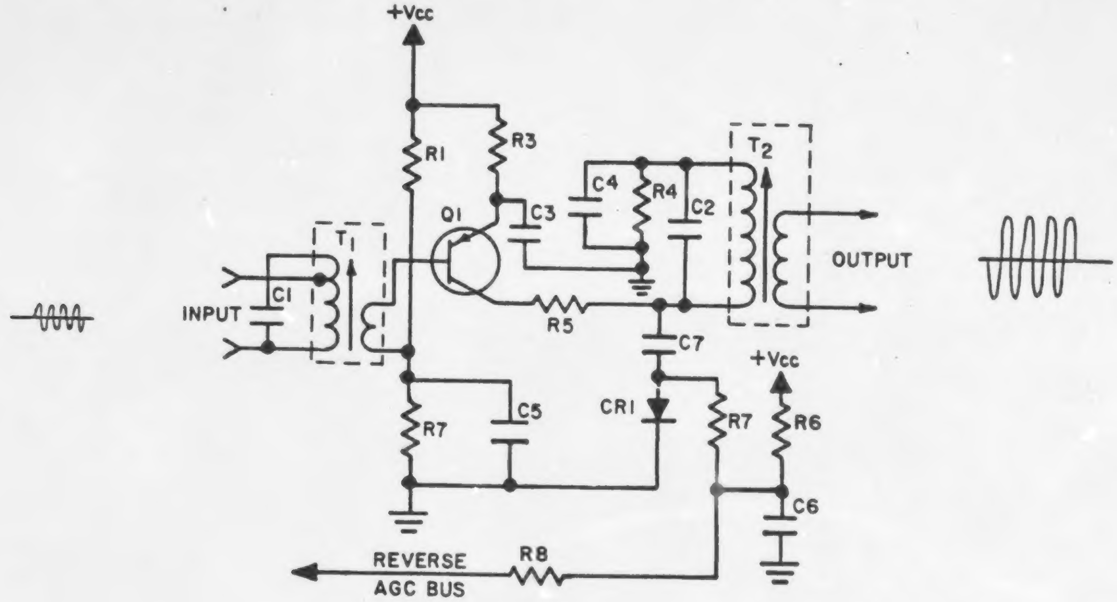


Figure 9

AUTOMATIC GAIN CONTROL (AGC)

The AGC components provide an automatic reverse bias gain control over previous RF and IF amplifier stages. The AGC voltage in a receiver is usually tied to an AGC "bus" which provides feedback to previous stages on the same bus.

In the figure, C7 couples a part of the IF output signal to CR1. This leaves a rectified small-positive average DC voltage at the junction of CR1, C7, and R7. This small positive voltage decreases toward zero as the amplitude of the IF signal increases enough in strength. R6 and R7 form a voltage divider between + V_{CC} and the AGC output voltage. As the positive voltage at the CR1, C7, and R7 junction decreases (but never becomes negative), the AGC output voltage becomes less positive. This lowers the AGC bias voltage on the bus and reduces the gain of previous stages. R8 and C6 filter the AGC voltage to produce a smooth DC level.

You will be using the "S" meter in the NIDA trainer as part of the Job Program for this lesson. The meter is often used in superheterodyne receivers to indicate the strength of received signals, and to help center-tune the receiver. Calibration for "S" meters can be in "S" units, decibels, or some other numerical scale units. In the NIDA trainer, calibration is on a scale from 0 to 10. The "S" meter on the NIDA trainer is found in the second IF amplifier stage.

Figure 10 shows the "S" meter circuit components in the NIDA trainer.

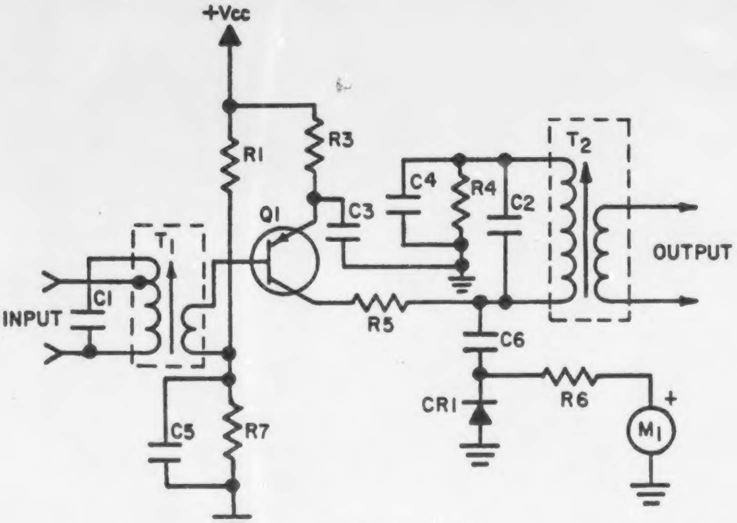


Figure 10

IF AMPLIFIER STAGE WITH "S" METER

For the meter circuit to operate, part of the IF signal is tapped off the Q1 collector circuit. The pulsating +DC voltage across the half-wave rectifier CR1 is applied to dropping resistor R6, and meter M1. The meter pointer indicates the average DC voltage level across CR1.

Technicians often use the "S" meter as a piece of built-in test equipment (BITE) to aid in troubleshooting. When a signal is tuned in, an "S" meter deflection indicates that receiver circuit problems are likely to be located in stages following the meter. If no deflection occurs, receiver problems are likely to be located in stages somewhere leading up to and including the meter circuit.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULATION WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 3

IF Amplifiers

1. IF amplifiers are used in receivers to establish high____________and provide the desired____________.

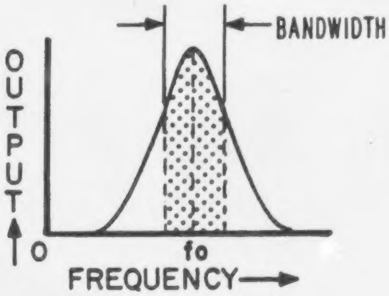
    1. selectivity, demodulation
    2. sensitivity, neutralization
    3. gain, bandwidth
    4. bias, feedback

2. In an IF amplifier____________tuning widens the bandwidth.

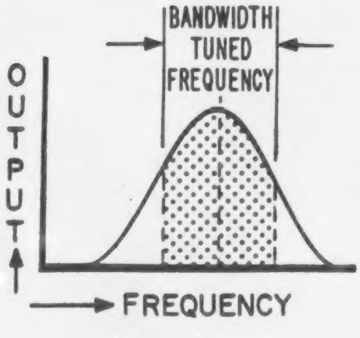
    1. stagger
    2. ganged
    3. variable
    4. synchronous

3. Which diagram best illustrates the frequency response curve for an IF amplifier using synchronous tuning?

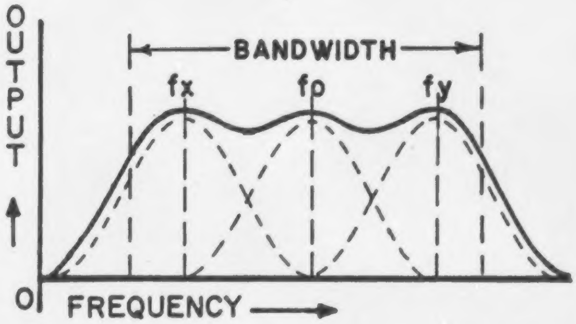
a.


BANDWIDTH
OUTPUT
O
fo
FREQUENCY

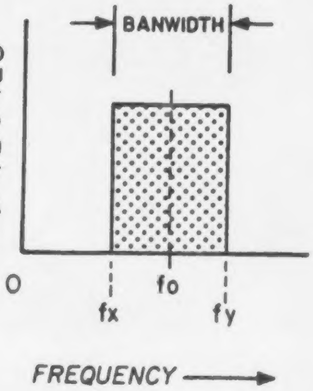
b.


BANDWIDTH TUNED FREQUENCY
OUTPUT
FREQUENCY

c.

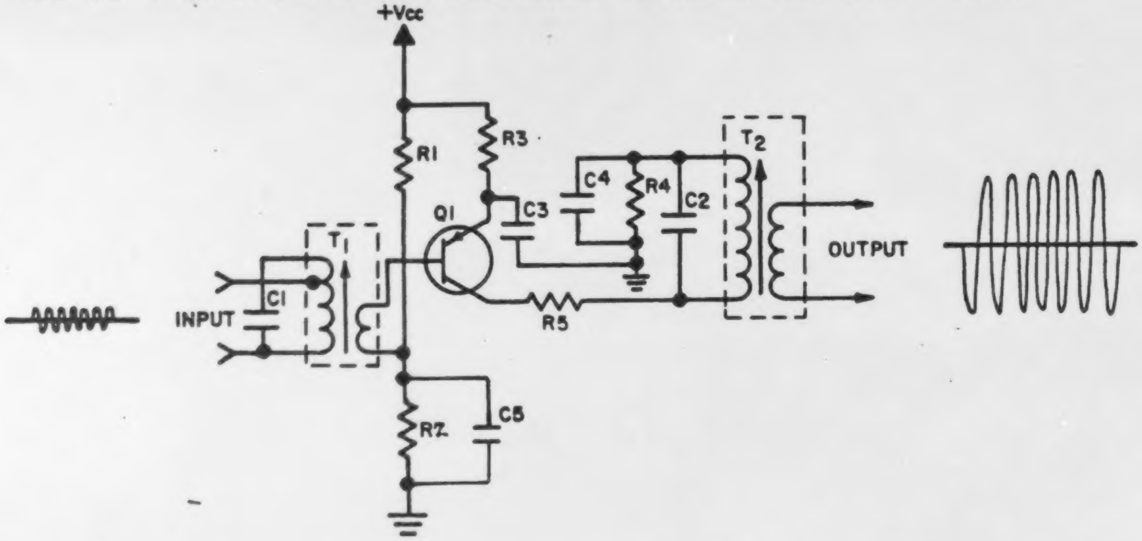

OUTPUT
BANDWIDTH
fx
fo
fy
O
FREQUENCY

d.


BANWIDTH
OUTPUT
O
fx
fo
fy
FREQUENCY

    1. a
    2. b
    3. c
    4. d

USE THE IF AMPLIFIER STAGE DIAGRAM BELOW TO ANSWER QUESTIONS 4 AND 5.



4. T1 and T2 are__________ ______________transformer couplings

   1. untuned broadband
   2. tuned inductive
   3. tuned capacitor
   4. untuned narrowband

5. Which components decouple the signal from the power supply?

   1. R3 and C3
   2. R4 and C4
   3. R2 and C5
   4. R5 and C2

6. An IF amplifier is_____________when the gain causes clipping of the output signal.

   1. neutralized
   2. biased
   3. rectified
   4. overdriven

7. An IF amplifier produces relatively small gain within a_________operating region.

   1. constant
   2. normal
   3. non-linear
   4. linear

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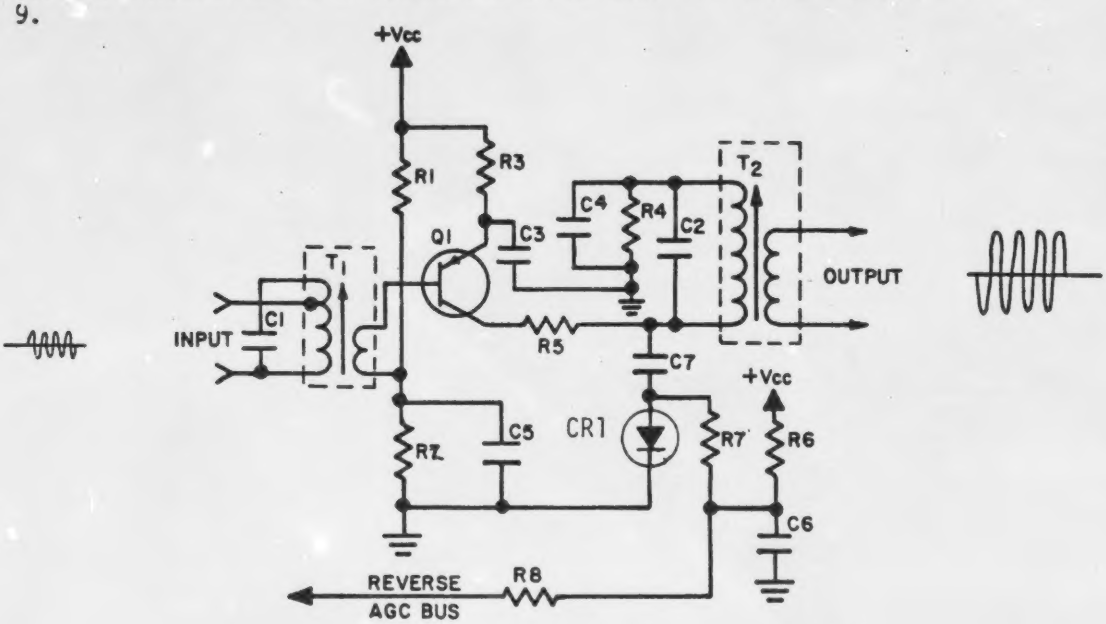
USE THE DIAGRAM OF AN IF AMPLIFIER STAGE BELOW TO ANSWER QUESTIONS 8 AND 9.


+Vcc
R1
R3
T2
C4
R4
C2
C3
Q1
T1
INPUT
C1
OUTPUT
R5
C7
+Vcc
CR1
R2
C5
R7
R6
C6
REVERSE AGC BUS
R8

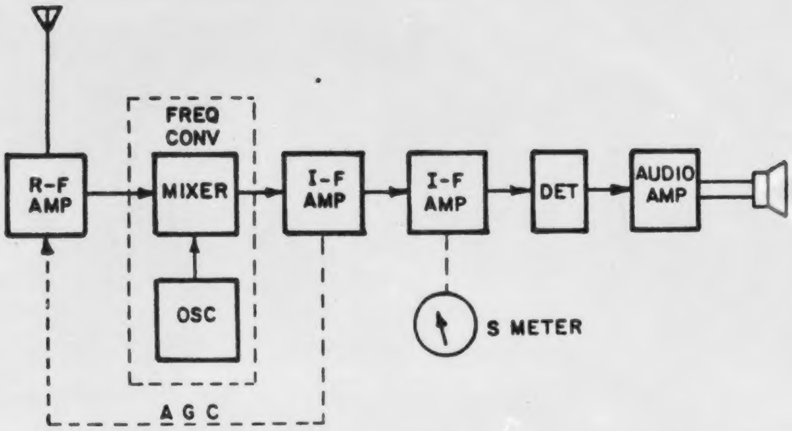
8. If the amplitude of the IF output signal increases high enough, the voltage at the junction of CR1, C7 and R7

   1. remains constant
   2. decreases toward zero
   3. increases toward zero
   4. increases from zero to more positive

9. The AGC circuit in the diagram provides ________________bias gain control.

   1. constant
   2. normal
   3. forward
   4. reverse

USE THE BLOCK DIAGRAM OF A RADIO RECEIVER BELOW TO ANSWER QUESTION 10.



10. As you tune in a station on your radio receiver, the "S" meter shows no deflection. There is normal audio output. You suspect a problem in the

    1. 2nd IF amplifier
    2. "S" meter circuit
    3. detector
    4. 1st IF amplifier

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY AND FEEL READY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULT WITH THE LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

FAULT ANALYSIS

(PAPER TROUBLESHOOTING)

FOR

MODULE 31, LESSON 3

NOW THAT YOU HAVE COMPLETED THE KNOWLEDGE SECTION OF THIS LESSON, YOU ARE READY FOR PAPER TROUBLESHOOTING.

THE COMPUTER WILL ASSIGN YOU A SET OF PAPER TROUBLESHOOTING PROBLEMS ON THE IF AMPLIFIER CIRCUIT. THESE PROBLEMS WILL HELP YOU DEVELOP THE MENTAL SKILLS REQUIRED IN ACTUAL TROUBLESHOOTING. YOU WILL BE GIVEN SYMPTOMS OF A FAILURE AND CIRCUIT MEASUREMENTS THAT WILL ALLOW YOU TO IDENTIFY THE PROBLEM.

AFTER YOU COMPLETE THE PAPER TROUBLESHOOTING SECTION, THE COMPUTER WILL ASSIGN YOU A PRACTICE TROUBLESHOOTING PROBLEM ON A FAULTY PRINTED CIRCUIT BOARD.

REMEMBER THAT REFERENCE VOLTAGES, WAVEFORMS, AND A SCHEMATIC ARE CONTAINED IN THIS STUDENT GUIDE FOR YOUR USE IN BOTH PAPER AND ACTUAL TROUBLESHOOTING PROBLEMS.

TERMINAL OBJECTIVE:

31.3.54 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in a solid state IF amplifier when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

ENABLING OBJECTIVE:

31.3.54.10 IDENTIFY the faulty component or circuit malfunction in a given IF amplifier circuit, given a schematic diagram and failure symptoms, by selecting the correct fault from a choice of four. 100% accuracy is required.*

Footnote *This objective is considered met upon successful completion of the terminal objective.

TROUBLESHOOTING PERFORMANCE TEST

DIRECTIONS: DO NOT WRITE IN THE PERFORMANCE TEST BOOKLET. MAKE ALL YOUR RESPONSES ON THE SIX STEP TROUBLESHOOTING SHEET SUPPLIED WITH THIS TEST PACKET. THIS PERFORMANCE TEST BOOKLET IS DESIGNATED TO AID YOU IN COMPLETING THE STANDARD SIX STEP TROUBLESHOOTING FORM. COMPLETE THE STEPS USING YOUR KNOWLEDGE AND SKILL OF THE CIRCUITS SHOWN. CONTACT YOUR LEARNING CENTER INSTRUCTOR IF YOU HAVE ANY QUESTIONS.

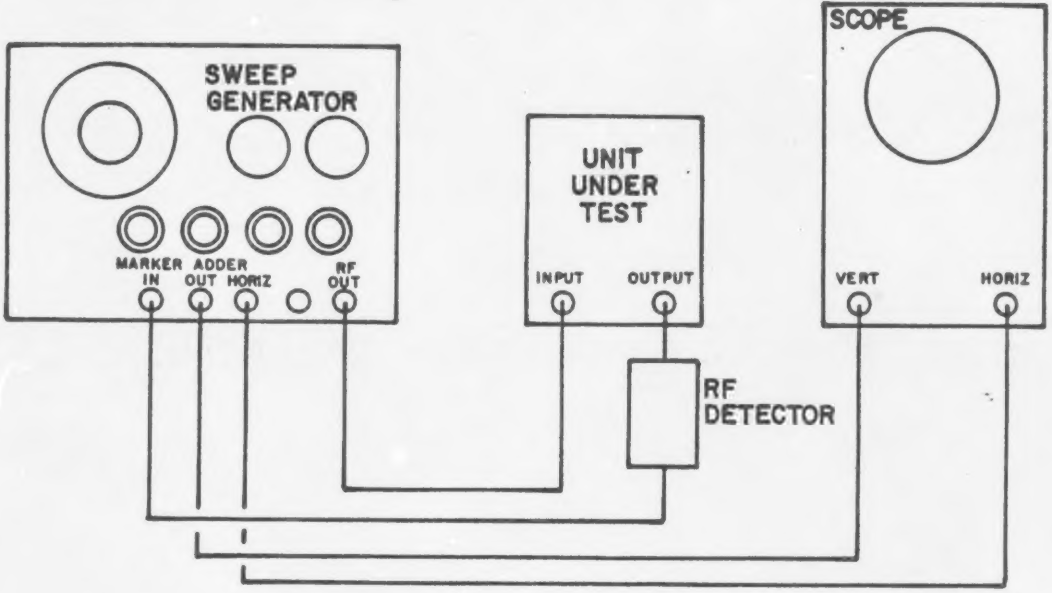

SWEEP GENERATOR
MARKER IN
ADDER OUT
HORIZ
RF OUT
UNIT UNDER TEST
INPUT
OUTPUT
RF DETECTOR
SCOPE
VERT
HORIZ

Figure 1

SET UP THE EQUIPMENT AS SHOWN IN FIGURE 1. SET THE SWEEP GENERATOR FOR A FREQUENCY OF 10.7 MHz. CONNECT THE BNC-ALLIGATOR CABLE TO PIN #3 OF THE 1st IF AMPLIFIER. ALL VOLTAGE AND RESISTANCE MEASUREMENTS WILL BE MADE WITH REFERENCE TO GROUND UNLESS THE PCB IS REMOVED TO MEASURE FRONT TO BACK RESISTANCE RATIOS OR TO MEASURE THE RESISTANCE OF A SPECIFIC RESISTOR.

TROUBLESHOOTING PERFORMANCE TEST

STEP ONE - SYMPTOM RECOGNITION

1. Does the equipment energized? ______________________________ yes/no

STEP TWO - SYMPTOM ELABORATION

1. Indication on the Signal Strength meter ______________________ yes/no

STEP THREE - LIST THE PROBABLE FAULTY FUNCTION(S)

1. First and second IF amplifiers

STEP FOUR - LOCALIZE THE FAULTY FUNCTION

1. Verify the probable faulty function by use of test equipment.
2. List the test points where voltages were obtained.
3. Reference voltages and resistances are listed in the voltage/resistance chart.
4. Be sure you list the reference voltage/resistance on the troubleshooting sheet for each measurement you make.

STEP FIVE - LOCALIZE THE FAULTY CIRCUIT/COMPONENT

1. List the test points where actual voltages were taken.
2. What circuit/component in the faulty function listed in step four is faulty?
3. If you have determined the faulty circuit but not the faulty component proceed to step six.

STEP SIX - FAILURE ANALYSIS

1. Secure the power and using the Simpson 260 take resistance checks.
    - a. Check front to back ratios on diodes.
    - b. Continuity checks on printed circuit board foil.
    - c. Capacitors can be shorted or open.
    - d. Resistors can be open.

TROUBLESHOOTING PERFORMANCE TEST

2. Explain in your own words why the component listed in steps five or six above would cause the symptoms listed in steps one and two of the six step troubleshooting procedure? Write your answer in the space provided on the troubleshooting form.

TAKE YOUR SIX STEP TROUBLESHOOTING SHEET TO YOUR LEARNING CENTER INSTRUCTOR FOR VERIFICATION AND EVALUATION.

VOLTAGE/RESISTANCE CHART

The following Voltages and Resistances were taken with a Simpson 260 multimeter, with the sweep generator set at 10.7 MHz and connected to Pin #3 of the 1st IF amplifier printed circuit board and the output taken from Pin #10 of the 2nd IF amplifier printed circuit board. All the Voltage and Resistance measurements were made with respect to ground or circuit common.

POINT of CHECK	VOLTAGE	RESISTANCE
Pin #6 Vcc	10.7 VDC	2.1 K ohms
V_E Q1 1st IF	8.2 VDC	3.3 K ohms
V_b Q1 1st IF	7.2 VDC	8.5 K ohms
V_C Q1 1st IF	1.9 VDC	730 ohms
V_E Q2 1st IF	8.5 VDC	3.4 K ohms
V_B Q2 1st IF	7.5 VDC	8.5 K ohms
V_C Q2 1st IF	1.4 VDC	600 ohms
V_E Q1 2nd IF	8.7 VDC	3.4 K ohms
V_B Q1 2nd IF	7.9 VDC	6.0 K ohms
V_C Q1 2nd IF	1.7 VDC	800 ohms

JOB PROGRAM
FOR
LESSON 3

IF Amplifiers

INTRODUCTION

This job program is designed to further your understanding of IF amplifiers, regarding bandwidth, frequency response, and gain. It should strengthen the important points you studied in the narrative, programmed instruction, and summary.

TERMINAL OBJECTIVE(S):

31.3.54 When the student completes this lesson (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state IF amplifiers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions. 100% accuracy is required.

ENABLING OBJECTIVE(S):

31.3.54.9 MEASURE and COMPARE frequency response and gain characteristics of IF amplifier circuits given a training device, circuit boards, test equipment and proper tools, schematic diagrams, and a job program containing reference data for comparison. Recorded data must be within limits stated in the job program.

SAFETY PRECAUTIONS

Observe all standard safety precautions. Beware of all exposed connections. An energized circuit may have dangerous voltages in it.

EQUIPMENT AND MATERIALS

1. Telonic 1232A Sweep Generator.
2. Dual Trace Oscilloscope.
3. RF Detector Model 8571.
4. NIDA 205 Transceiver Trainer.
5. 1 X Probes Tektronics P6028.
6. BNC-BNC Cables (2 long).
7. BNC-BNC Cable (2 short).
8. BNC-Alligator Clip Cable (2 short).

PROCEDURES

1. Set up the sweep generator as follows:
   - a. Sweep frequency dial to "0".
   - b. Sweep width control to mid-range.
   - c. Marker width to "wide". Marker size to mid-range.
   - d. Sweep mode to "1-50". VERN/MAN control to mid-range.
   - e. RF level control fully CW.
   - f. Attenuation controls to the "0" position.
   - g. All markers switches to the "off" position.
2. Set up the oscilloscope as follows:
   - a. All display mode switches out (X-Y mode).
   - b. Channel 1 Volts/Div control to 1.
   - c. Channel 2 Volts/Div control to 2.
3. Turn the NIDA 205 transceiver over and remove the bottom cover. Leave the bottom cover off for the remainder of this job program.
4. Using extreme care remove the socket J-1 from its connector on the RF amplifier PCB. This prevents any interference from the local oscillator affecting your measurements in the IF amplifier.

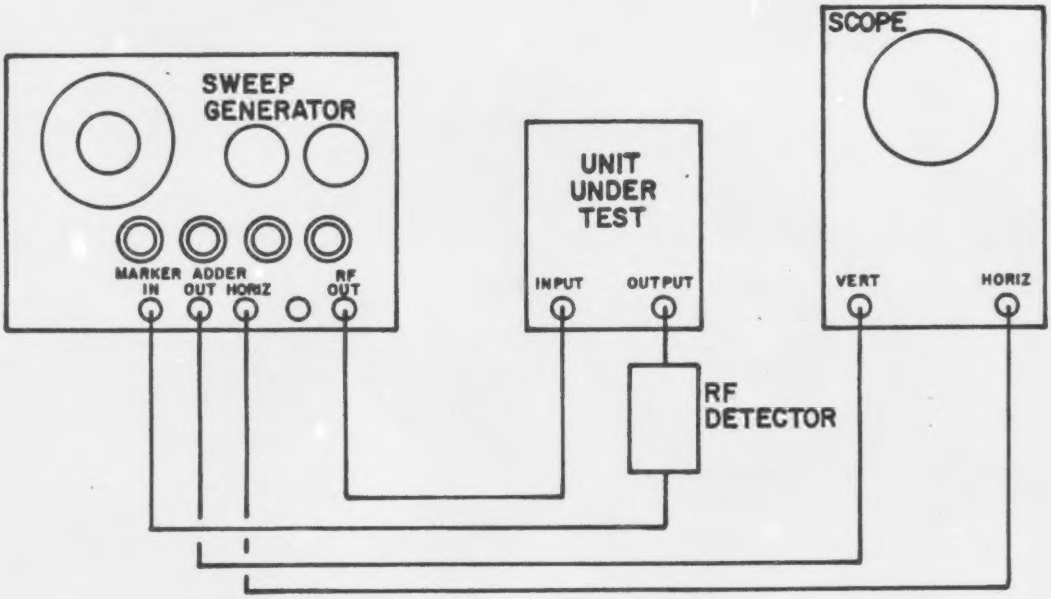

SWEEP GENERATOR
MARKER IN
ADDER OUT
HORIZ
RF OUT
UNIT UNDER TEST
INPUT
OUTPUT
RF DETECTOR
SCOPE
VERT
HORIZ

Figure 1

5. Connect the equipment as shown in Figure 1. Connect the RF output from the sweep generator between Pin #3 and circuit common of the 1st IF amplifier PCB.

6. Set up the sweep generator for a frequency of 10.7 MHz as viewed on the oscilloscope.

NOTE: The procedure for this was covered in the job program of lesson Thirty One-2 and since practice was required on your part, step 6 should not be difficult for you.

7. Place the RF detector probe on Pin #11, the output of the 1st IF amplifier assembly.

8. Turn the "0-70" dB attenuator switch on the sweep generator for a 40 dB attenuation of the signal on the scope.

9. Turn the sweep frequency dial until you have centered the signal on the scope.

   a. Calculate the amplitude of the signal on the scope___________.

   b. Using the formula, calculate the amplitude of the signal at the 70.7% power points__________.

10. Turn the RF level on the sweep generator fully CCW.

11. Using the vertical position control on the scope, place the top of the waveform exactly on the center horizontal line.

    a. Using the oscilloscope, calculate the amplitude of the signal at the 70.7% power points________. Remember that the full range of the RF level control is 3 dB.

    b. Do steps 9b above and 11a correspond?________yes/no.

    c. Should they correspond?_________yes/no

12. Turn the RF level control fully CW. Using the sweep width control, expand the sweep. Turn on the .1 MHz (100 kHz) markers. Count the number of markers from the right of the vertical center line to the horizontal center line.

    a. What is the bandwidth?______________

    b. What is the frequency response?________________

13. Turn off the .1 MHz (100 kHz) markers.

14. Set the "0-70" dB attenuator switch to 20.

15. Set the channel 1 Volts/Div control to .05. Calculate the amplitude of the signal at Pin #3 of the 1st IF amplifier as viewed at the vertical center line of the scope____________.

16. Set the channel 1 Volts/Div control to 2. Calculate the amplitude of the signal at Pin #11 of the 1st IF amplifier___________.

    a. Calculate the gain of the 1st IF amplifier PCB_______________.

NOTE: Certain facts should be obvious to you by this time in the job program.

1. The transformers are both step-down transformers.
2. 6.2 V is too great an amplitude signal to apply to Q1 in the 2nd IF amplifier without destroying Q1.
3. Due to the fact that the 2nd IF amplifier has only one amplifier stage, its gain will be less than the gain of the 1st IF amplifier which has two amplifier stages.
4. The signal at Pin #2 of the 2nd If amplifier will be the same, in all respects, with the signal at Pin #11 of the 1st IF amplifier.

17. Set the "0-70" dB attenuator switch to 60. Set the channel 1 Volts/Div control on the scope to .2.

17. Set the "0-70" dB attenuator switch to 60. Set the channel 1 Volts/Div control on the scope to .2.

18. Calculate the amplitude of the signal at Pin #2 of the 2nd IF amplifier ____________.

19. Calculate the amplitude of the signal at Pin #10 of the 2nd If amplifier using the channel 1 Volts/Div control to decrease the amplitude of the signal__________.

    a. What is the gain of the 2nd IF amplifier?_______________.

    b. Using methods previously given in this job program, and counting the markers to the left of the vertical center line determine the bandwidth _____________.

    c. What is the frequency response?_____________.

    d. Is the bandwidth narrower than the BW in step 12?__________yes/no.

NOTE: The remainder of this job program will be concerned with AGC (automatic gain control). On the 1st IF amplifier, notice CR1 and C10; CR1 is the AGC diode and C10 is the AGC capacitor. The AGC voltage is coupled back to the RF amplifier through Pin #2 of the 1st IF amplifier PCB.

20. Connect the equipment as follows:

    a. Sweep generator frequency to 10.7 MHz.

    b. Connect the BNC-alligator clip cable from the RF output jack to Pin #3 of the 1st IF amplifier.

    c. Connect the second BNC-alligator clip cable from the markers in jack to the top of C10.

    d. Set the "0-70" attenuator switch to 70 dB and the "0-10" attenuator switch to "0".

21. Set the controls on the oscilloscope as follows:

    a. Channel 1 Volts/Div control to .2.

    b. Channel 1 vertical position control until a sweep appears at the center of the scope.

22. Change the "0-70" dB attenuator switch in steps of 10 dB until you see the DC level on the scope go in a less positive direction.

NOTE: Notice that from 70 dB to 30 dB the signal was so weak that no AGC voltage was developed since there was no change in the sweep voltage. Notice also that as you changed from 30 to 20 dB the DC level decreased in a less positive direction indicating that AGC voltage is being developed across C10.

23. Turn the attenuator switch to 10 dB. Notice that the DC voltage increased further in a negative direction.

24. Study the overall schematic diagram at the back of this module.

    a. What is happening to the bias on Q1 of the RF amplifier as the signal strength increases?________________.

    b. Does the signal strength meter confirm your observations in step 24a? ____________yes/no.

    c. Does the RF amplifier use forward or reverse AGC?____________yes/no.

25. Disconnect all cables from the NIDA 205 Transceiver Trainer.

26. Turn off the power to the Transceiver Trainer.

27. Turn the Transceiver up-side-down. Very carefully connect the connector to the RF amplifier.

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON TEST. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

INFORMATION SHEETS
FOR
TROUBLESHOOTING PERFORMANCE TEST

INTRODUCTION:

Using the following six step troubleshooting procedure will aid you in determining which component is faulty. In the split method of troubleshooting, Pin #11, the output of the 1st IF amplifier assembly, has been selected as the starting point for this performance test. Based on your interpretation of the scope presentation at this point, you can determine which direction you should go.

EQUIPMENT:

1. NIDA 205 Transceiver Trainer
2. Telonic 1232A Sweep Generator
3. NIDA 207 Oscilloscope
4. NIDA PCB's 205-4FM and 205-5FM
5. Simpson 260 Multimeter and Test Leads
6. RF Detector Probe
7. BNC-BNC cables (2 long)
8. BNC-BNC cables (2 short)
9. BNC-Alligator Clip cable (1 short)

INSTRUCTIONS:

1. Each student is required to determine the defective component in a prefaulted IF amplifier assembly. You will be allowed 45 minutes of troubleshooting time on the equipment.

2. Standard test equipment will be available to you in the form of an oscilloscope, a sweep generator, and a Simpson 260 multimeter. You will be expected to observe all safety precautions throughout the test. A safety violation will result in an automatic failure of the performance test. In that event you will be counselled and given remedial training.

3. You will take a numbered position in the test room. After briefing by the Learning Center Instructor you will fill out the heading of the troubleshooting form. On a signal from the Learning Center Instructor, you will start the test. If at any time during the test you should require assistance, raise your hand. DO NOT LEAVE YOUR POSITION. A Learning Center Instructor will assist you with your trouble. You will set up the equipment according to the specifications given in the troubleshooting performance test procedures in this booklet. All voltages and resistances measured will be within +/- 20% tolerance with those given in the voltage/resistance chart at the end of this performance test.

TROUBLESHOOTING PERFORMANCE TEST

4. You must identify the faulty component to pass this performance test.

5. If you do not understand these instructions, raise your hand and ask your Learning Center Instructor. If you do understand these instructions and upon a signal from your Learning Center Instructor, you may now begin the Performance Test on the next page.

SCHEMATIC DIAGRAM

FM IF AMPLIFIERS

PC 205-4

PC 205-5

P.P. 188, 189

SUMMARY
Lesson 4

Video Amplifiers

Many types of electronic equipment which produce a visual display require video amplifiers. The ideal video amplifier should have a frequency response curve resembling Figure 1.

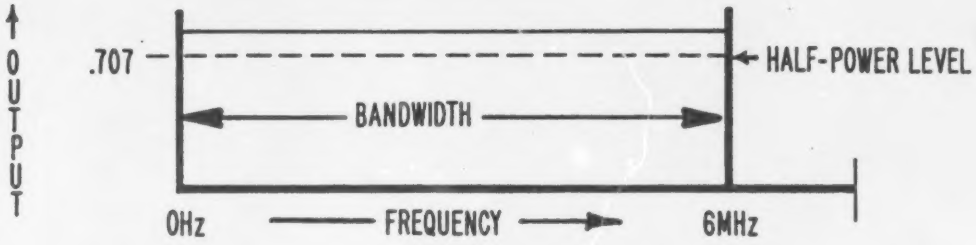


FIGURE 1

IDEAL VIDEO AMPLIFIER RESPONSE CURVE

Figure 2 shows the typical response curves for actual transformer-coupled and resistance-capacitive (RC) coupled amplifiers.

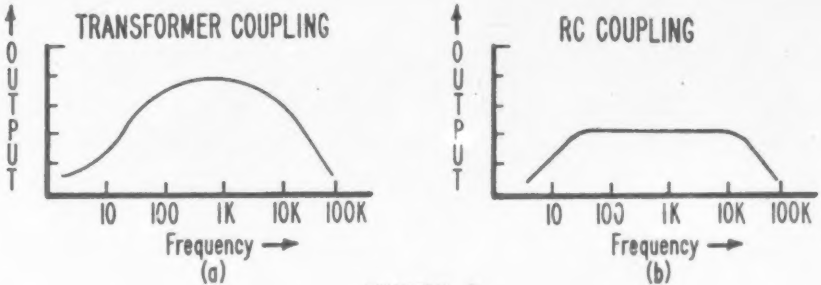


FIGURE 2

AMPLIFIER RESPONSE CURVES

Although RC coupled amplifiers provide the wider bandwidth, they fall short of the wide bandwidth requirements of video amplifiers.

Figure 3 can be referenced to show what limits video amplifier low frequency response.

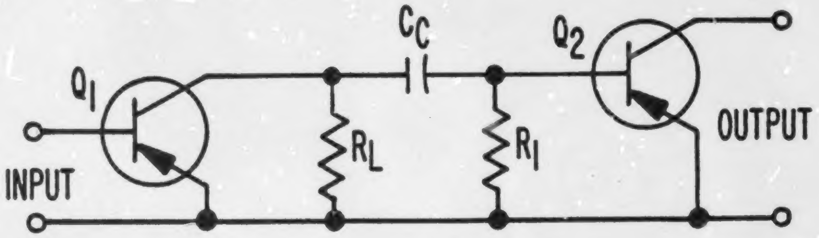


FIGURE 3

AC EQUIVALENT-RC COUPLED AMPLIFIER

At low frequencies, the capacitive reactance (Xc) of Cc is relatively high causing some signal voltage to drop across Cc instead of across R1. Thus, less voltage is felt across R1 which reduces overall amplifier gain at low frequencies.

One method to partially compensate for low frequency response loss is to use a larger value coupling capacitor. Another type of method is to add the RC network shown in Figure 4.

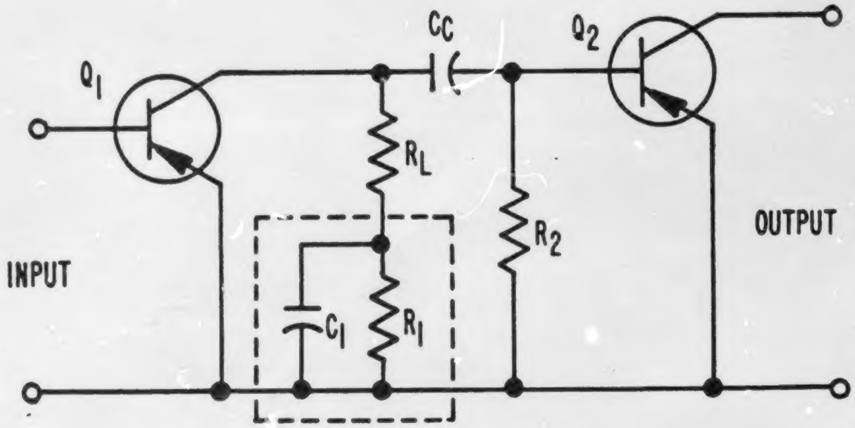


FIGURE 4

AC EQUIVALENT - LOW FREQUENCY COMPENSATION CIRCUIT

At low frequencies, the Xc of C1 is large enough so that C1 acts as an open. Therefore, the RC network has an impedance equal to R1. This makes the total load impedance for Q1 equal to RL + R1, which increases amplifier gain by compensating for the Cc voltage drop. At high frequencies, C1 acts to short the RC network, which returns the gain from Q1 to that produced by RL alone. Another method for amplifying low frequencies uses DC (direct coupling) between stages. This method will be seen in Module 34.

Figure 5 shows what limits video amplifier high frequency response.

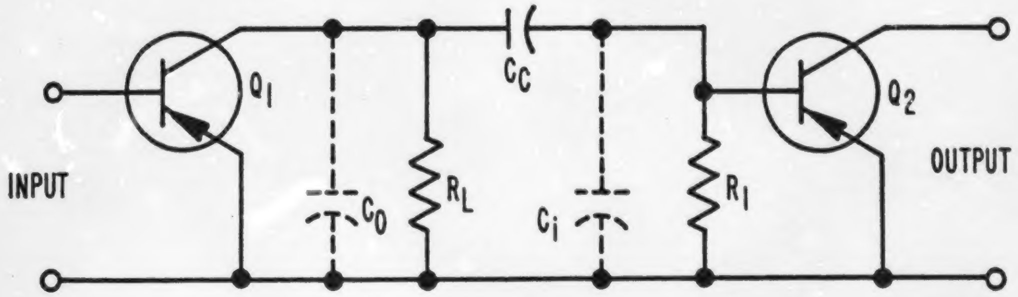


FIGURE 5

AC EQUIVALENT - STRAY CAPACITANCE

The input and output stray capacitances Co and Ci have low reactances at high frequencies, and shunt the signal to ground. These stray capacitances result from the close spacing between wires, foils, components, and the input/output capacity of active devices.

One method to compensate for high frequency signal loss is to place an inductor in parallel with Co and Ci as shown in Figure 6.

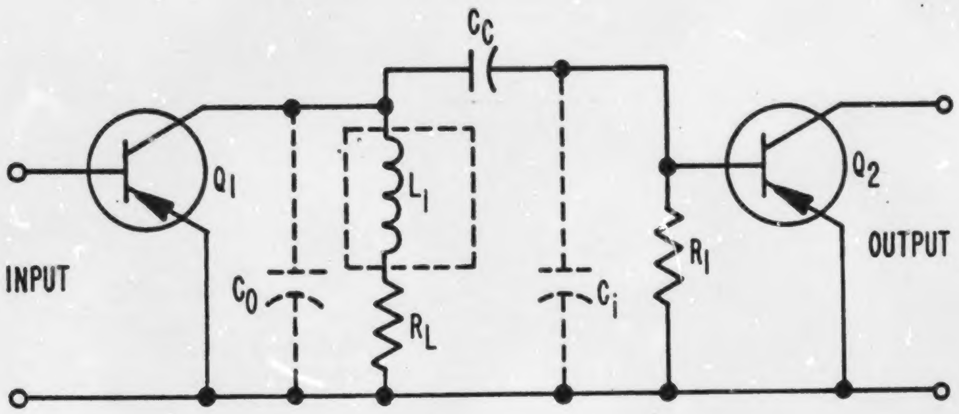


FIGURE 6

"SHUNT" HIGH FREQUENCY COMPENSATION (AC EQUIVALENT)

At high frequencies, Co, Ci and L1 form a parallel resonant circuit which, at resonance, develops an increased output impedance from Q1. This type of high frequency compensation is called shunt compensation, or shunt peaking. The shunt compensation circuit has a wide bandwidth, and an Fo above the frequency response of the uncompensated amplifier circuit.

Shunt type compensation may not improve the high frequency response of video amplifiers enough for some applications. The circuit can be further improved by adding an inductor in series with the signal path and Ci as shown in Figure 7.

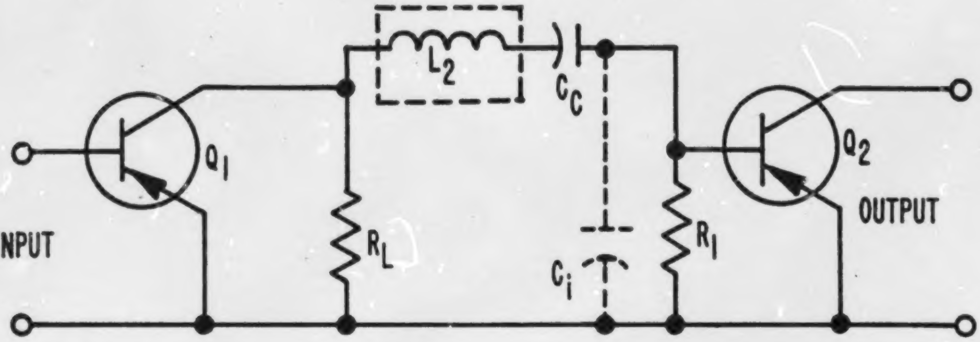


FIGURE 7

"SERIES" HIGH FREQUENCY COMPENSATION (AC EQUIVALENT)

At high frequencies, the combination L2 - Ci forms a series resonant circuit to the signal path. At resonance, the impedance in this LC circuit is at a minimum and the voltage across the reactive components are at a maximum. Therefore, the voltage developed by Ci is maximum at Fo and will be felt across R1 and fed to the base of Q2. This method of increasing amplifier gain is called series compensation, or series peaking. If the value of L2 is chosen properly, the Fo of the series compensation circuit will occur above the frequency response of the shunt compensation circuit. This will further increase the amplifier's frequency response.

Figure 8 shows the frequency response curve for a video amplifier with combined low and high frequency compensation added.

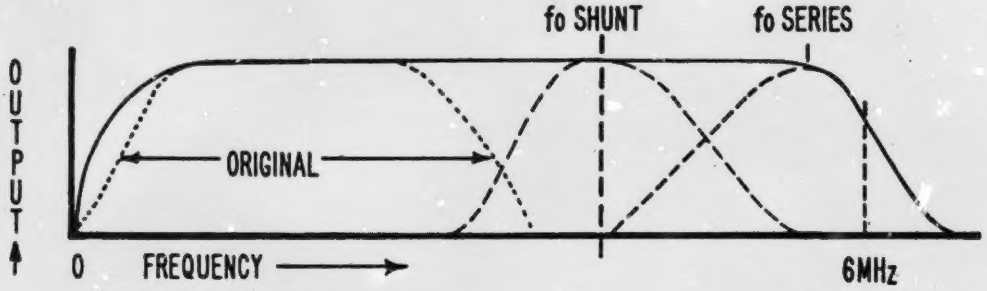


FIGURE 8

COMPENSATED VIDEO AMPLIFIER RESPONSE

This fully compensated RC coupled video amplifier has a frequency response from about 30 Hz to 6 MHz.

Figure 9 shows the schematic diagram of a two-stage video amplifier as found in the NIDA trainer. A description of component functions follows.

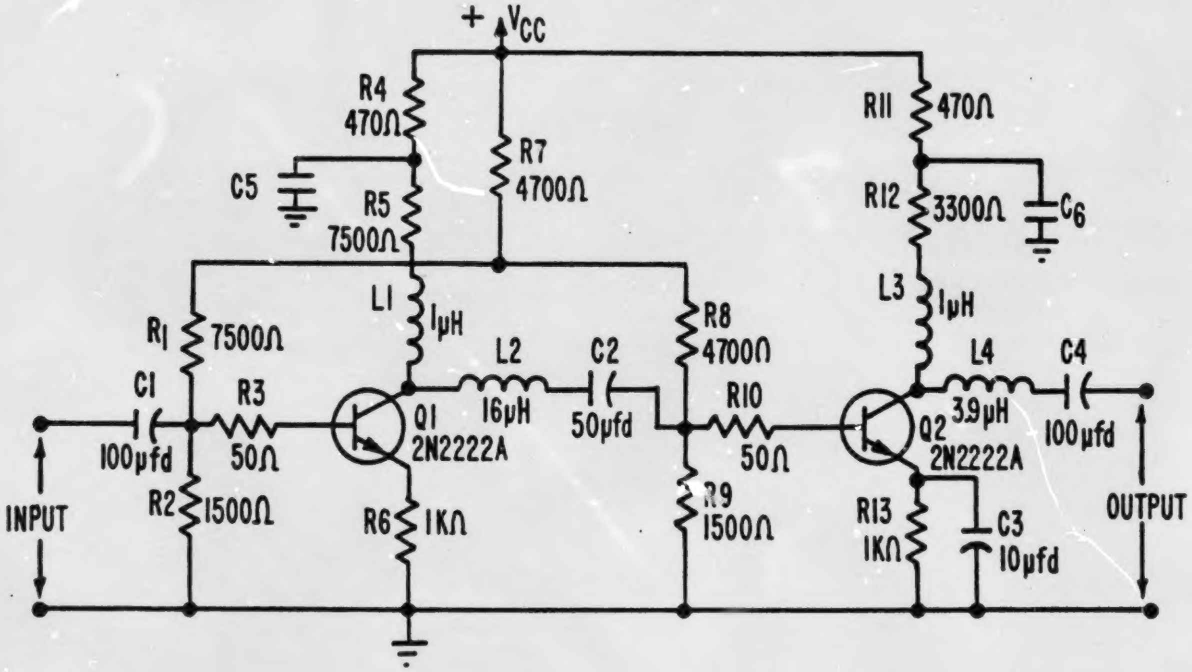

+ VCC
R4 470Ω
R7 4700Ω
C5
R5 7500Ω
R11 470Ω
R12 3300Ω
C6
L3 1μH
L1 1μH
R1 7500Ω
L2 16μH
C2 50μfd
R8 4700Ω
L4 3.9μH
C4 100μfd
C1 100μfd
R3 50Ω
Q1 2N2222A
R10 50Ω
Q2 2N2222A
R2 1500Ω
R6 1KΩ
R9 1500Ω
R13 1KΩ
C3 10μfd
INPUT
OUTPUT

FIGURE 9

2-STAGE VIDEO AMPLIFIER-ACTUAL CIRCUIT

Class A forward bias is provided for Q1 by R1 and R2, and for Q2 by R8 and R9. R7 completes the voltage divider from Vcc with these networks. Emitter stabilization is provided by R6 and R13. R13 is bypassed by C3 to prevent degeneration and loss of gain. R6 is not bypassed to improve low and high frequency response at the cost of some gain.

The interstage video signal coupling C1, C2, and C4 have large values to improve low frequency response. The R4-C5 and R11-C6 decoupling components separate the signal path from the DC power supply, and prevent the amplifier from becoming an oscillator. The shunt high frequency peaking coils L1 and L3 are connected to the normal collector load resistors R5 and R12. The series high frequency peaking coils are L2 and L4.

R10 acts to reduce the Q, and broaden the bandwidth, of the L2-C2 series compensation network. R3 acts to perform a similar function in a previous amplifier stage.

The frequency response for a video amplifier can be measured using a sweep frequency generator as shown in the test set-up in Figure 10.

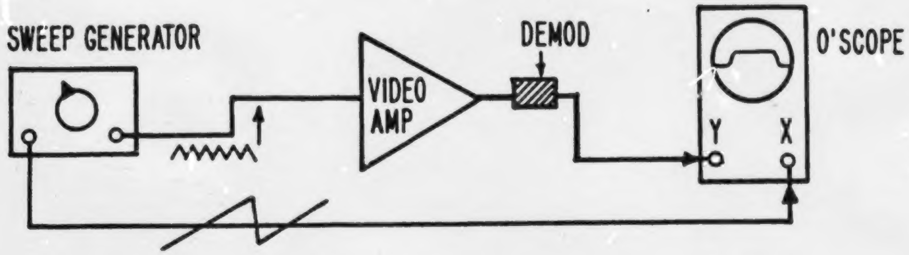


FIGURE 10

VIDEO AMPLIFIER FREQUENCY RESPONSE TEST

If the generator is set to sweep from 0 Hz to 10 MHz, the output signal from a test amplifier would resemble the display on the oscilloscope shown in the figure. A technician can troubleshoot the video amplifier by comparing the actual frequency response curve with the expected normal frequency response curve. Deficiencies in either high or low frequency responses indicate which components may be faulty.

The frequency response for a video amplifier also can be measured using a square wave generator as shown in the test set-up in Figure 11.

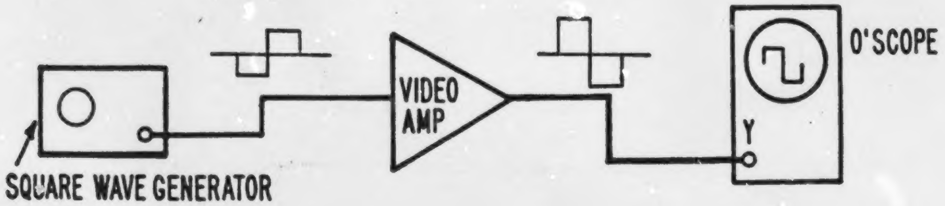

O'SCOPE
VIDEO AMP
Y
SQUARE WAVE GENERATOR

FIGURE 11

SQUARE WAVE-AMPLIFIER TEST

Accurate reproduction of the square wave indicates good frequency response in a video amplifier. Any distortion of the square wave indicates a problem in frequency response.

In theory, a square wave is the result of combining a fundamental sine wave frequency with an infinite number of odd-numbered harmonic frequencies. In practice, a video amplifier which accurately reproduces a square wave is capable of amplifying a fundamental frequency and at least the first 10 odd-numbered harmonics. The display produced by a video amplifier with good and poor frequency responses are shown in Figure 12.

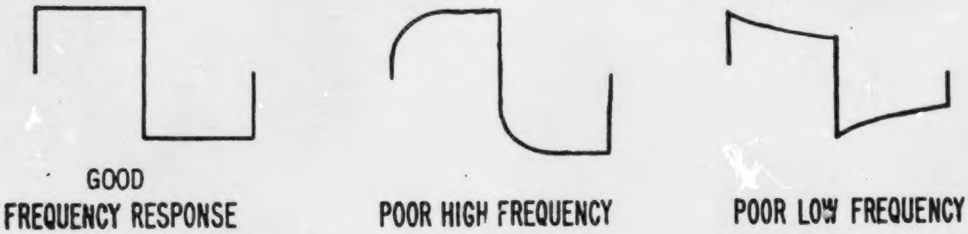

GOOD FREQUENCY RESPONSE
POOR HIGH FREQUENCY
POOR LOW FREQUENCY

FIGURE 12

SQUARE WAVE DISPLAYS AND FREQUENCY RESPONSE

You will have the opportunity to operate and troubleshoot a video amplifier in the Job Program for this lesson.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULATION WITH LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON 4

Video Amplifiers

TERMINAL OBJECTIVE(S):

31.4.55 When the student completes this lesson, (s)he will be able to TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state video amplifiers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions. 100% accuracy is required.

ENABLING OBJECTIVE(S):

When the student completes this lesson, (s)he will be able to:

31.4.55.1 IDENTIFY the causes of low frequency response losses in a basic RF coupled amplifier circuit by selecting the correct statement from a choice of four. 100% accuracy is required.

31.4.55.2 IDENTIFY the components which accomplish low frequency compensation in an AC equivalent video amplifier circuit, given a schematic diagram, by selecting the correct list of components from a choice of four. 100% accuracy is required.

31.4.55.3 IDENTIFY the causes of high frequency response losses in a basic RC coupled amplifier circuit by selecting the correct statement from a choice of four. 100% accuracy is required.

31.4.55.4 IDENTIFY the components which accomplish high frequency compensation in an AC equivalent video amplifier circuit, given a schematic diagram, by selecting the correct list of components from a choice of four. 100% accuracy is required.

31.4.55.5 IDENTIFY the function of components that improve frequency response in a video amplifier cirucit, given a schematic diagram, by selecting the correct statement from a choice of four. 100% accuracy is required.

31.4.55.6 IDENTIFY the frequency response deficiency (high or low) indicated by output waveforms from a video amplifier, given illustration of output waveforms, by selecting the correct indication from a choice of four. 100% accuracy is required.

PROGRESS CHECK
LESSON 4

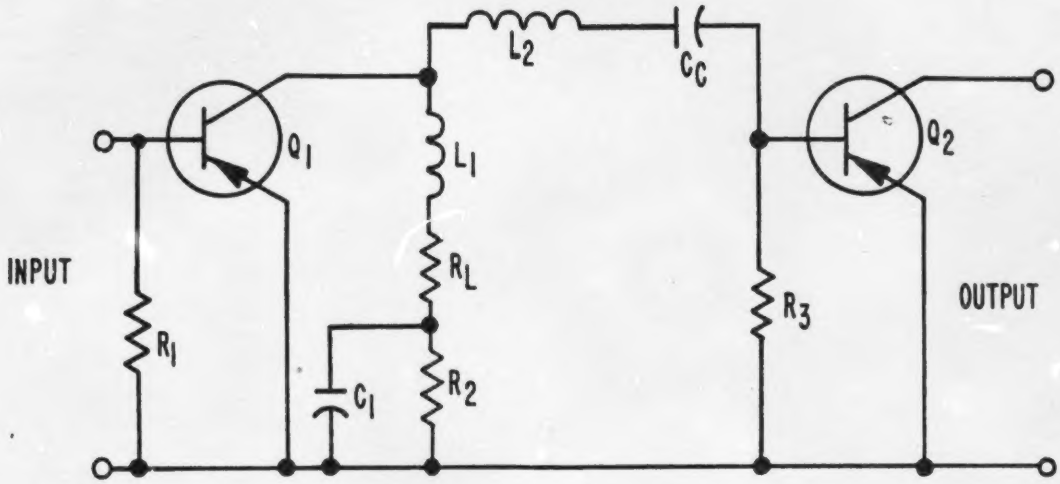
Video Amplifiers

1. In an RC coupled amplifier, low frequency losses are caused by the (increased/decreased) voltage drop across the interstage _______ _________.

2. In an RC coupled amplifier, the spacing between wires and components at high frequencies causes

   a. signal instability in the coupling capacitor
   b. an increase in amplifier frequency response
   c. the loss of high frequency amplification
   d. an increase in the center frequency of the amplifier

USE THE DIAGRAM BELOW OF AN AC EQUIVALENT, TWO-STAGE VIDEO AMPLIFIER CIRCUIT TO ANSWER QUESTIONS 3 THROUGH 6.



3. Low frequency compensation is provided by components ________ and ________.

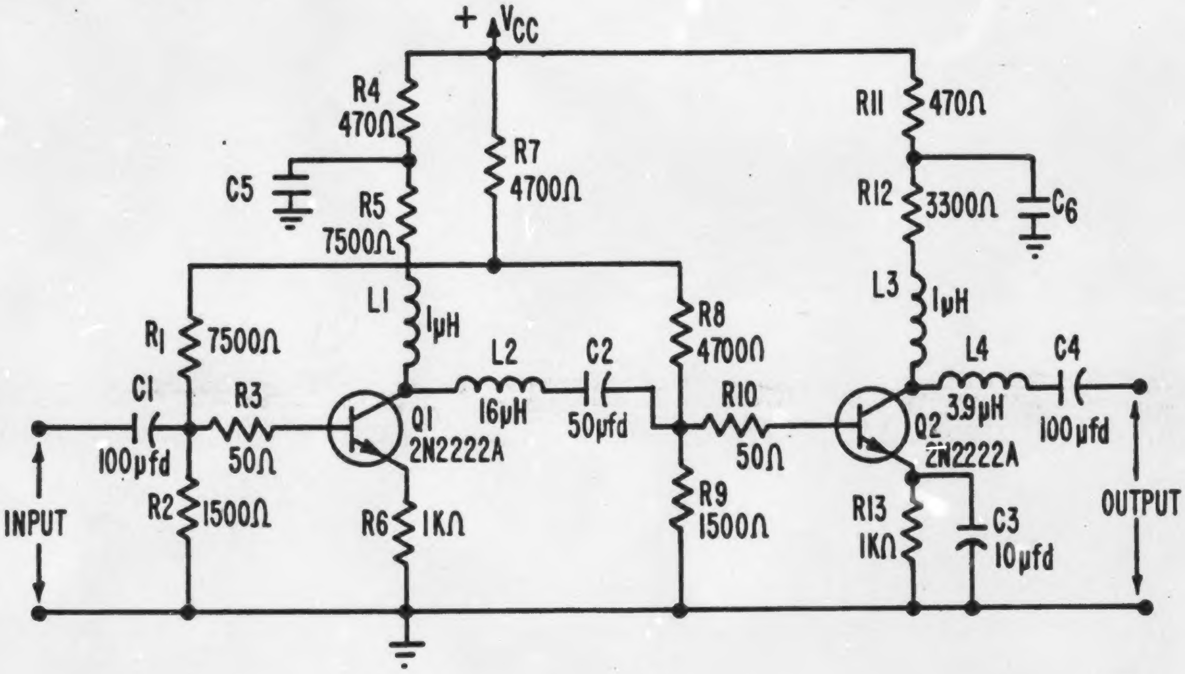
4. High frequency compensation is provided by components ________ and ________.

5. At low frequencies, the load impedance of Q1 is increased by the additional resistance of

   a. RL
   b. R1
   c. R2
   d. R3

6. Series peaking is provided by component ________.

USE THE DIAGRAM BELOW OF A TWO-STAGE VIDEO AMPLIFIER CIRCUIT TO ANSWER QUESTIONS 7 THROUGH 9.


+ VCC
R4 470Ω
C5
R5 7500Ω
R7 4700Ω
R11 470Ω
R12 3300Ω
C6
L1 1μH
L3 1μH
R1 7500Ω
C1 100μfd
R3 50Ω
Q1 2N2222A
L2 16μH
C2 50μfd
R8 4700Ω
R10 50Ω
Q2 2N2222A
L4 3.9μH
C4 100μfd
R2 1500Ω
R6 1KΩ
R9 1500Ω
R13 1KΩ
C3 10μfd
INPUT
OUTPUT

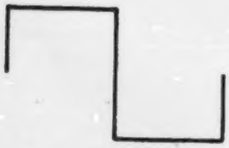
7. Shunt peaking is provided by components ________ and ________ .

8. Class A forward bias is provided to the second stage by components

   a. R7, R8, and R9
   b. R11, R12, and R13
   c. R9 and R10
   d. R10 and R13

9. Amplifier oscillation in the first stage is prevented by components ________ and ________.

USE THE FIGURE BELOW TO ANSWER QUESTION 10.



10. The figure shows the output signal from a video amplifier with a square wave input. The output signal indicates that the frequency response is ________ at low frequencies and ________ at high frequencies.

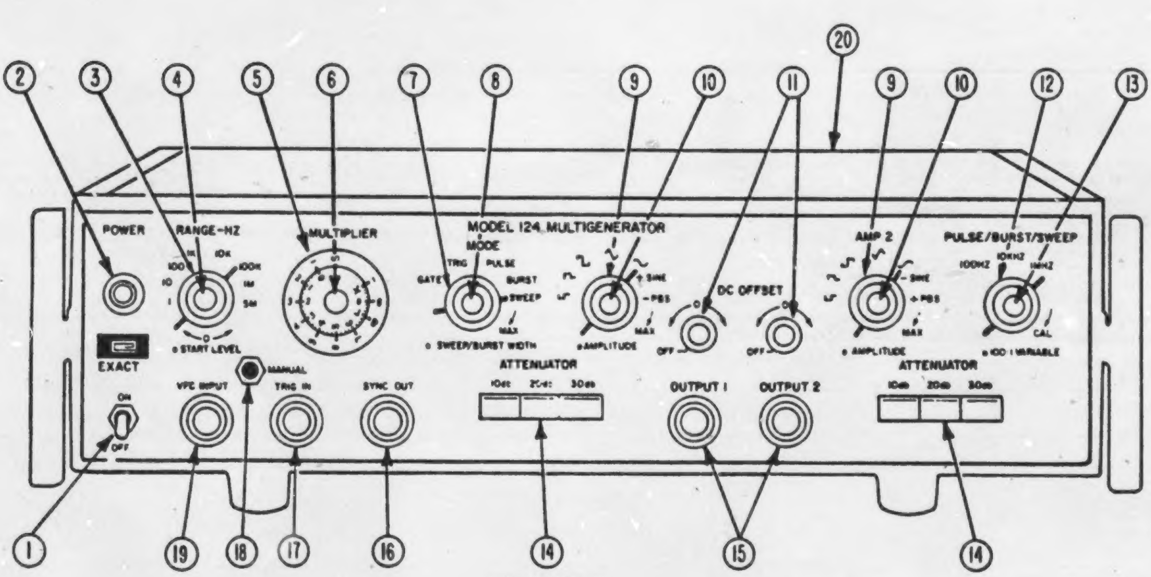
    a. good, good
    b. good, poor
    c. poor, good
    d. poor, poor

CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY AND FEEL READY, PROCEED TO THE JOB PROGRAM. IF YOU INCORRECTLY ANSWER ONLY A FEW OF THE PROGRESS CHECK QUESTIONS, THE CORRECT ANSWER PAGE WILL REFER YOU TO THE APPROPRIATE PAGES, PARAGRAPHS, OR FRAMES SO THAT YOU CAN RESTUDY THE PARTS OF THIS LESSON YOU ARE HAVING DIFFICULTY WITH. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

INFORMATION SHEET
LESSON 4

Exact Model 124 Multigenerator

The Exact Model 124 Multigenerator is a combination SINE, SQUARE, TRIANGLE, SWEEP, TONEBURST, and PULSE GENERATOR in one compact and versatile package. It is a signal generator used to troubleshoot and align RF, IF, Video and Audio circuits. You can see the importance of this if you are troubleshooting a radar set. You would need an RF signal generator, a square wave generator for your video circuits, an audio oscillator for your master timer, etc. All these generators are given to you in one compact package.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⑳
⑨
⑩
⑫
⑬
POWER
RANGE-HZ
100
1K
10K
100K
10
1M
1
5M
0
START LEVEL
MULTIPLIER
MODEL 124 MULTIGENERATOR
MODE
TRIG
PULSE
GATE
BURST
SWEEP
MAX
SWEEP/BURST WIDTH
SINE
PBS
MAX
AMPLITUDE
DC OFFSET
0
OFF
0
OFF
AMP 2
SINE
PBS
MAX
AMPLITUDE
PULSE/BURST/SWEEP
100HZ
10KHZ
1MHZ
CAL
100 : 1 VARIABLE
EXACT
ON
OFF
VFC INPUT
MANUAL
TRIG IN
SYNC OUT
ATTENUATOR
10db
20db
30db
OUTPUT 1
OUTPUT 2
ATTENUATOR
10db
20db
30db
①
⑲
⑱
⑰
⑯
⑭
⑮
⑭

FIGURE 1
FRONT PANEL MODEL 124

FUNCTION OF CONTROLS, SWITCHES AND CONNECTORS

Refer to Figure 1 for the below listed controls and connectors.

1. Power Switch - Turns instrument On and Off.
2. Power Indicator Lamp - Visual indication when power is On.

3. Range Switch - Selects desired frequency range.

4. Start Level - Varies the lockout level or phase of the triangle and sine waveforms with respect to the square wave.

5. Multiplier Dial - Provides calibrated fixed steps between range settings. Each step equals 10% of range. The "S" position places the generator in the Search mode.

6. Multiplier Vernier - Allows variable adjustment of frequency between fixed steps of the Multiplier dial.

7. Mode Switch - Selects main generator modes of operation.

8. Sweep/Burst Width - Controls sweep width when in sweep mode and burst width in burst mode.

9. Function Switch, Amp 1 and Amp 2 - Selects the desired function.

10. Amplitude, Amp 1 and Amp 2 - Provides 20 dB variable attenuation of the output amplitude.

11. D.C. Offset Switch - The Off position disables the offset potentiometer. The offset potentiometer manually adjusts the D.C. reference of the output waveform selected by the Function switch.

12. Pulse/Burst/Sweep Switch - Selects desired frequency of Pulse/Burst/Sweep Generator.

13. 100:1 VAR - Provides 100:1 variable frequency to cover all frequencies between 1 MHz and 1 Hz.

14. Attenuator, Amp 1 and Amp 2 - Selects desired amount of attenuation at Amp 1 or Amp 2 outputs. Pushbutton attenuators provide 10 dB steps (adding) to 60 dB.

15. Output Jack, Amp 1 and Amp 2 - 50Ω output jack for all waveforms selected by the Function switch.

16. Sync Out - Provides Sync pulse for external equipment. Sync pulse is coincident with internal square wave.

17. Trig In - Provides input for external gating and triggering signals for the main generator.

18. Manual Pushbutton - Provides manual gating and triggering signal.

19. VCF Input - Provides external input for voltage control of frequency or sweeping.

JOB PROGRAM
FOR
LESSON 4

Video Amplifiers

INTRODUCTION:

This Job Program is designed to permit you to analyze the operation of video amplifiers and to see the results of high frequency compensating networks. It will reinforce your knowledge of the video amplifiers you studied in the narrative, programmed instruction or summary. All voltages and resistances measured should be within +/- 20% tolerance with those given in the answer sheet to the job program.

TERMINAL OBJECTIVE(S):

31.4.55 When the student completes this lesson, (s)he will be able to TROUBLESHOOT and IDENTIFY components and/or circuit malfunctions in solid state video amplifiers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions. 100% accuracy is required.

ENABLING OBJECTIVE(S):

When the student completes this lesson, (s)he will be able to:

31.4.55.7 MEASURE AND COMPARE frequency response and gain characteristics of video amplifier circuits given a training device, circuit boards, test equipment and proper tools, schematic diagrams, and a job program containing references for comparison. Recorded data must be within limits stated in the job program.

SAFETY PRECAUTIONS

Observe all standard safety precautions. Beware of all open and exposed connections; an energized circuit may have dangerous voltages present.

EQUIPMENT AND MATERIALS

1. Oscilloscope
2. Exact 124 Multigenerator
3. NIDA 205 Transceiver Trainer
4. Video amplifier PC 205-5V
5. 1X Probe TEKTRONIX P6028 (2)
6. BNC-BNC connector cable (1 long)
7. Shorting wire with two alligator clips
8. Schematic diagram of the PC 205-5V

PROCEDURES

1. Remove the top cover from the NIDA 205 Transceiver Trainer. Remove all printed circuit boards from the chassis.

2. Insert the PC205-5V printed circuit board in the PC 205-5 position.

3. Refer to the schematic diagram of the PC 205-5V (fold out page).

4. Set up the multigenerator as follows:

   a. Set the Range-Hz switch to 10 kHz. Set the start level control to mid-range.

   b. Set the multiplier switch to position 4. Set the vernier control in the center of the Multiplier switch to position 4. Use this control in conjunction with the oscilloscope stability control to stabilize the sweep.

   c. Set the Mode switch to the "SWEEP" position. Set the Sweep/Burst/Width control fully CCW.

   d. Set the "AMP 1" switch to the third position from fully CCW. Set the Amplitude control fully CCW.

   e. Set both DC offset controls to mid-range.

   f. Set the Attenuator switches for an attenuation of the signal by 20 dB. This will prevent overdriving the input amplifier stage of the video amplifiers.

   g. Set the PULSE/BURST/SWEEP switch to 1 MHz. Set the 100:1 variable control to the "cal" position.

   h. Connect a 1X probe to the "Output 1" jack.

5. Set up the oscilloscope as follows:

   a. Set the Display Mode switches for channel #1 operation.

   b. Set the Volts/Div control for channel #1 to the .2 position.

   c. Set the Time/Div control to 50 usec.

   d. Set the Triggering level and stability controls to mid-range.

   e. Set the Trigger source switch to "INT."

   f. Set all other switches to the "AC" position.

   g. Connect a 1X probe to the channel #1 input of the oscilloscope.

6. Connect the two 1X probes together and turn on the oscilloscope and the multigenerator.

7. Refer to step #3b above. Manipulate the vernier control on the multigenerator and the stability control on the oscilloscope until you obtain a stable presentation.

8. Using the oscilloscope, calculate the amplitude of the waveform shown __________. This signal will be used as the input to the 2 stage video amplifier circuit board.

NOTE: In all cases involving the use of various types of signal generators it is very important that the signal being supplied by the generator never be permitted to exceed the bias on the transistor or severe distortion and inaccurate presentations will result.

9. Connect the 1X probe from the multigenerator to the top of C1 in the video amplifier and the 1X probe from the oscilloscope to the bottom of L1. This is the collector of Q1. Energize the NIDA 205 Transceiver Trainer.

   a. Calculate the amplitude of the signal on the scope __________.

   b. Calculate the gain of the amplifier using the information obtained in step #8 and step #9a __________.

   c. Study the schematic diagram and try to figure out why the gain of the circuit is so low __________.

10. Turn the channel #1 Volts/Div control on the scope to the .5 position.

11. Deenergize the NIDA 205 Transceiver Trainer.

12. Notice the 10uf capacitor with one end soldered to the bottom of R6. Connect the shorting wire with the two alligator clips between the unconnected end of this capacitor and the top of R6. You have now provided an emitter bypass capacitor for the first video amplifier stage.

13. Energize the NIDA 205 Transceiver Trainer.

   a. What happened to the gain? ____________________.

   b. What happened to the low frequency response? ____________________.

NOTE: Now you can see that an emitter bypass capacitor will increase the gain of an amplifier stage and if the emitter bypass capacitor should open the amplifier gain will be very low. REMEMBER THIS. It is very important in troubleshooting.

14. Deenergize the NIDA 205 Transceiver Trainer.

15. Remove the shorting wire from the capacitor.

16. Energize the NIDA 205 Transceiver Trainer.

17. Connect the oscilloscope probe to the top of the output capacitor at pin #7.

NOTE: There is a 1000 pf capacitor at the lower right hand corner of the PCB connected to pin #12. The purpose of this capacitor, which is NOT a part of the circuit is to show you what happens to your high frequency response when the peaking coils are bypassed to ground.

18. Change the controls on the multigenerator as follows:

    a. Set the Range-Hz control to 100 K.

    b. Set the multiplier control to position 3.

    c. Remove all signal attenuation by setting all attenuator switches to the "out" position.

    d. You may vary the vernier control in the center of the multiplier for a stable presentation after setting up the oscilloscope.

19. Change the settings on the oscilloscope as follows:

    a. Change the channel #1 Volts/Div control to 5.

    b. Change the Time/Div control to 10 usec.

20. Deenergize the NIDA 205 Transceiver Trainer.

21. Using the shorting wire with the two alligator clips, connect 1 clip to the 1000 pf capacitor lead and the other clip to the bottom of L3.

22. Energize the NIDA 205 Transceiver Trainer and notice the effect on the waveform on the scope.

    a. What happened to the high frequency response? ______________.

23. Go through the procedures listed in steps #20, #21 and #22 except connect the capacitor to the bottom of L4 and view the waveform on the scope.

NOTE: In most cases using transistorized circuitry, it is impossible for a technician to measure voltages directly on the emitter, base or collector of a transistor; therefore you must place your meter lead on the end of the component which is connected to these elements.

24. Using the information given in the above note, measure the DC voltages on the emitter, base and collector of Q1 and Q2, and check these voltages with voltage/waveform chart at the end of this lesson.

25. Attenuate the signal from the multigenerator by a factor of 20 dB.

26. Connect a BNC-BNC cable from the "sync out" jack on the multigenerator to the trigger source jack on the oscilloscope. The purpose for this is so you can see the phase reversal of the amplifiers.

27. Set the trigger source switch on the oscilloscope to "EXT."

28. Using the 1X probe from the oscilloscope trace the signal through each transistor. Notice the phase shift between input and output. Compare your waveforms with the waveforms in the voltage/waveform chart at the end of this lesson.

    a. Calculate the gain of Q2 ______________.

    b. Calculate the total gain of the video amplifiers ______________.

NOTE: You have now completed the Job Program for video amplifiers. You have seen how shunt and series high frequency compensating coils (peaking coils) effect the operation of a video amplifier and how an emitter bypass capacitor effects the operation of a circuit.

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON TEST. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULATION WITH THE LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

FAULT ANALYSIS

(PAPER TROUBLESHOOTING)

FOR

MODULE 31, LESSON 4

NOW THAT YOU HAVE COMPLETED THE KNOWLEDGE SECTION OF THIS LESSON, YOU ARE READY FOR PAPER TROUBLESHOOTING.

THE COMPUTER WILL ASSIGN YOU A SET OF PAPER TROUBLESHOOTING PROBLEMS ON THE VIDEO AMPLIFIER CIRCUIT. THESE PROBLEMS WILL HELP YOU DEVELOP THE MENTAL SKILLS REQUIRED IN ACTUAL TROUBLESHOOTING. YOU WILL BE GIVEN SYMPTOMS OF A FAILURE AND CIRCUIT MEASUREMENTS THAT WILL ALLOW YOU TO IDENTIFY THE PROBLEM.

AFTER YOU COMPLETE THE PAPER TROUBLESHOOTING SECTION, THE COMPUTER WILL ASSIGN YOU A PRACTICE TROUBLESHOOTING PROBLEM ON A FAULTY PRINTED CIRCUIT BOARD.

REMEMBER THAT REFERENCE VOLTAGES, WAVEFORMS, AND A SCHEMATIC ARE CONTAINED IN THIS STUDENT GUIDE FOR YOUR USE IN BOTH PAPER AND ACTUAL TROUBLESHOOTING PROBLEMS.

TERMINAL OBJECTIVE:

31.4.55 TROUBLESHOOT and IDENTIFY faulty components and/or circuit malfunctions in solid state video amplifiers when given a training device, prefaulted circuit board, necessary test equipment, schematic diagram and instructions.

ENABLING OBJECTIVE:

31.3.54.10 IDENTIFY the faulty component or circuit malfunction in a given video amplifier circuit, given a schematic diagram and failure symptoms, by selecting the correct fault from a choice of four. 100% accuracy is required.*

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*This objective is considered met upon successful completion of the terminal objective.

INFORMATION SHEETS
FOR
TROUBLESHOOTING PERFORMANCE TEST

INTRODUCTION:

Using the following six step troubleshooting procedure will aid you in determining which component is faulty. In the split method of troubleshooting, the collector of Q1 has been selected as the starting point for this performance test. Based on your interpretation of the scope presentation at this point, you can determine which direction you should go.

EQUIPMENT:

1. NIDA 205 Transceiver Trainer
2. NIDA 207 Oscilloscope
3. Exact 124 Multigenerator
4. NIDA PCB 205-5V Video Amplifier
5. Simpson 260 Multimeter and Test Leads
6. 1X P6028 Tektronic Probes (2)
7. Schematic Diagram of NIDA PCB 205-5V Video Amplifier

INSTRUCTIONS:

1. Each student is required to determine the defective component in a prefaulted Video Amplifier. You will be allowed 45 minutes of troubleshooting time on the equipment.

2. Standard test equipment will be available to you in the form of an oscilloscope, a multigenerator, and a Simpson 260 multimeter. You will be expected to observe all safety precautions throughout the test. A safety violation will result in an automatic failure of the performance test. In that event you will be counselled and given remedial training.

3. You will take a numbered position in the test room. After briefing by the Learning Center Instructor you will fill out the heading of the troubleshooting form. On a signal from the Learning Center Instructor you will then start the test. If at any time during the test you should require assistance, raise your hand. DO NOT LEAVE YOUR POSITION. A Learning Center Instructor will assist you with your trouble.

4. You must identify the faulty component to pass this performance test.

5. If you do not understand these instructions raise your hand and ask your Learning Center Instructor. If you do understand these instructions and upon a signal from your Learning Center Instructor you may now begin the Performance Test on the next page.

TROUBLESHOOTING PERFORMANCE TEST

DIRECTIONS: DO NOT WRITE IN THE PERFORMANCE TEST BOOKLET. MAKE ALL YOUR RESPONSES ON THE SIX STEP TROUBLESHOOTING SHEET SUPPLIED WITH THE TEST PACKET. THIS PERFORMANCE TEST BOOKLET IS DESIGNED TO AID YOU IN COMPLETING THE STANDARD SIX STEP TROUBLESHOOTING FORM. COMPLETE THE STEPS USING YOUR KNOWLEDGE AND SKILL OF THE CIRCUITS SHOWN. CONTACT YOUR LEARNING CENTER INSTRUCTOR IF YOU HAVE ANY QUESTIONS.

SET UP THE EQUIPMENT THE SAME AS YOU DID IN THE JOB PROGRAM. ALL WAVEFORMS, VOLTAGES AND RESISTANCES WILL BE MEASURED WITH REFERENCE TO GROUND UNLESS THE PCB IS REMOVED TO MEASURE FRONT TO BACK RESISTANCE RATIOS OR TO MEASURE THE RESISTANCE OF A SPECIFIC RESISTOR. ALL MEASURED VOLTAGES AND RESISTANCES SHOULD BE WITHIN +/- 20% TOLERANCE WITH THOSE GIVEN IN THE VOLTAGE/RESISTANCE CHART AT THE END OF THIS PERFORMANCE TEST.

STEP ONE - SYMPTOM RECOGNITION

1. Does the equipment energize? __________________________ yes/no.

STEP TWO - SYMPTOM ELABORATION

2. No symptom elaboration. Proceed to step 3. Front panel meter is not in the circuit.

STEP THREE - LIST THE PROBABLE FAULTY FUNCTION(S)

1. First and second Video amplifiers

STEP FOUR - LOCALIZE THE FAULTY FUNCTION

1. Verify the probable faulty function by use of test equipment.
2. List the test points where voltages/waveforms were obtained.
3. Reference voltages/waveforms/resistances are listed in the voltage/waveform/resistance chart.
4. Be sure you list the reference voltage/resistance on the troubleshooting sheet for each measurement you make.

STEP FIVE - LOCALIZE THE FAULTY CIRCUIT/COMPONENT

1. List the test points where actual voltages were taken.
2. What circuit/component in the faulty function listed in step four is faulty?
3. If you have determined the faulty circuit but not the faulty component proceed to step six.

TROUBLESHOOTING PERFORMANCE TEST

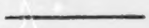
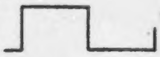
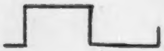
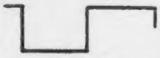
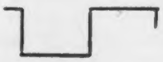
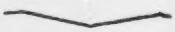
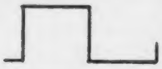
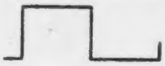
STEP SIX - FAILURE ANALYSIS

1. Secure the power and using the Simpson 260 take resistance checks.
   - a. Check front to back ratios on diodes.
   - b. Continuity checks on printed circuit board foil.
   - c. Capacitors can be shorted or open.
   - d. Resistors can be open.
2. Explain in your own words why the component listed in steps five or six above would cause the symptoms listed in steps one and two of the six step troubleshooting procedure. Write your answer in the space provided on the troubleshooting form.

TAKE YOUR SIX STEP TROUBLESHOOTING SHEET TO YOUR LEARNING CENTER INSTRUCTOR FOR VERIFICATION AND EVALUATION.

TROUBLESHOOTING
FOR
VOLTAGE/RESISTANCE/WAVEFORM CHART

The following voltages, resistances and waveforms were taken with a Simpson 260 multimeter and an oscilloscope with the scope and the multigenerator set up according to the instructions in the job program, steps #17, #18, #19 and #25 through #28. The output from the multigenerator is connected to Pin #5 of the video amplifier and the output is taken from Pin #7 of the video amplifier. All voltages, resistances and waveforms were taken with respect to ground or circuit common.

Point of Check	Voltage	Resistance	Waveform
Pin #6	10.2 VDC	1.9 K ohms	 10.2 VDC
V_B Q1	1.0 VDC	1.4 K ohms	 0.18 V
V_E Q1	0.48 VDC	1 K ohm	 0.16 V
V_C Q1	6.4 VDC	12 K ohms	 0.2V
V_B Q2	1.67 VDC	1.4 K ohms	 0.2 V
V_E Q2	1.25 VDC	1 K ohm	 0.02V
V_C Q2	5.8 VDC	6.5 ohms	 9.5 V
Pin #7	0 VDC	850 K ohms	 9.5 V

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SCHEMATIC DIAGRAM

VIDEO AMPLIFIER

PC 205-5V

P.P. 216, 217

ANSWER SHEETS
FOR
MODULES
THIRTY
THIRTY ONE

STUDENT'S GUIDE

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 1

Voltage Multipliers

		REFERENCES	
QUESTION NO.	CORRECT ANSWER	Narrative Ref. Pages	P.I. Ref. Frames
1.	a	37	1-3
2.	a	37	4-13
3.	b	39	14-17
4.	b	40	14-17
5.	c	41	14-17
6.	d	41	14-17
7.	a	41	14-17
8.	c	38	4-13
9.	b	42	18-24

ANSWER SHEET
FOR
JOB PROGRAM
LESSON 1

10.	a. 44.7 Vpk	+ or - 5%
	b. 31.6 VAC	+ or - 5%
11.	a. 60 Hz	
	b. Half-wave	
12.	132 VDC	+ or - 5%
13.	Three times	
14.	87.0 VDC	+ or - 5%
15	Two thirds	
16.	44.4 VDC	+ or - 5%
17.	One-third	
18.	a. 2:1	
19.	C1-5, CR2-5, CR3-5, C2-5 and R1-5	
20	CR1-5, C3-5 and R2-5	
21.	To provide a long discharge time for C2-5 and C3-5	
22.	a. 50V	
	b. 44 VDC	+ or - 5%
	c. The meter movement would be destroyed	
24.	44.4 VDC	+ or - 5%

THE ABOVE TOLERANCES ARE +/- 5% WHEN TAKEN WITH A DVM AND +/- 20% WHEN USING A VOM (SIMPSON 260).

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 2

Transistor, Voltage and Current Regulators

		REFERENCES	
QUESTION NO.	CORRECT ANSWER	Narrative Ref. Pages	P.I. Ref. Frames
1.	a		1-6
2.	b		7-12
3.	c		7-12
4.	b		7-12
5.	a		13-17
6.	b		13-17
7.	a		18-23
8.	b		18-23
9.	d		24-29
10.	d		30-33
11.	b		30-33
12.	c		24-29
13.	d		30-33
14.	d		30-33
15.	d		30-33
16.	c		30-33
17.	c		34-38
18.	b		34-38
19.	a		39-41
20.	c		39-41

ANSWER SHEET
FOR
JOB PROGRAM
LESSON 2

Transistor, Voltage and Current Regulators

11. 1.5 Amps. 1VDC

12. a. increased
    b. unregulated

13. 29 VDC 1.3 Amps.

14. a. remained the same
    b. decreased
    c. 0.3 Amps.
    d. yes
    e. 0.3 A to 1.3 A or 1 Amp.

18. V_C = 28.8 VDC
    V_B = 15.23 VDC
    V_E = 14.66 VDC

19. 0.57 VDC

21. V_C = 27.7 VDC
    V_B = 15.20 VDC
    V_E = 14.63 VDC

22. 0.57 VDC

24. V_C = 30.2 VDC
    V_B = 15.28 VDC
    V_E = 14.71 VDC

25. 0.57 VDC
    a. 0.00
    b. remained the same

30. 39.1 VDC 0.6A 15VDC

31. a. 31.4 VDC
    b. 15 VDC
    c. 16.4 VDC
    d. decreased
    e. yes

ANSWER SHEET
FOR
JOB PROGRAM
LESSON 2

Transistor, Voltage and Current Regulators

32. a. 41.3 VDC
    b. 15.0 VDC
    c. 26.3 VDC
    d. yes

33. $V_C = 17.7$ VDC
    $V_B = 37.2$ VDC
    $V_E = 37.7$ VDC

34. $V_C = 17.7$ VDC
    $V_B = 33.4$ VDC
    $V_E = 33.9$ VDC

35. 0.5 VDC

36. 0.5 VDC

37. constant

40.

CCW	0.00 VDC	0.69 VDC	0.69 VDC
0.3 A	0.50 VDC	1.62 VDC	1.12 VDC
0.6 A	1.05 VDC	2.24 VDC	1.19 VDC

a. no
b. no
c. There is no voltage across R2 with R5 fully CW so no current is flowing through it. The transistors Q1 and Q2 cut-off; or words to that effect.

43. 1.02 VDC

44. yes

47. 0.682 VDC

49. 4.64 VDC
    a. 3.985 VDC
    b. CW
    c. CCW

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 3

SCR Power Supplies

QUESTION NO.	CORRECT ANSWER	REFERENCES Narrative Ref. Pages	 P.I. Ref. Frames
1.	b	184	4 & 5
2.	c	186	4, 5 & 8
3.	c	186	8
4.	c	186	8
5.	d	186	9
6.	b	185	9
7.	c	186	14
8.	b	188	14 & 15
9.	b	187	18 & 19
10.	a	192	19
11.	d	192	21
12.	b	191	24

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 4

SCR Regulated Power Supplies

Question No	REFERENCES	
	Narrative Req. Pages	P.I. Ref. Frames
1. c	233-234	1-4
2. c Q1	235	5-10
3. b	235	5-10
4. c	236	5-10
5. a	241	19-21
6. b	234-235	12-18
7. b	239	12-18
8. c	238	19-21
9. c	239	19-21
10. d	241	12-18

ANSWER SHEET
FOR
JOB PROGRAM
LESSON 4

SCR Regulated Power Supplies

8. 6 VDC (min) 23 VDC (max)

11. a. To gate the SCR's
    b. 6.2 V (±) 0.5 V

13. a. 85 V (±) 0.5 V
    b. 30 V (±) 0.5 V
    c. 2.3 msec (±) .5 msec

14. a. Remained the same
    b. Yes
    c. 2.5 msec (±) .5 msec

15. a. Remained the same
    b. Yes
    c. 2.0 msec (±) .5 msec

17. a. Decreasing
    b. Decreasing
    c. Later

19. 21.0 VDC 2.5 msec (±) .5 msec

21. 6.5 VDC 1.5 msec (±) .5 msec

23. 23 VDC 3.2 msec (±) .5 msec

25. a. Decreasing
    b. Later
    c. Decreasing
    d. Decreasing

27. a. Increasing
    b. Earlier

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 1

RF, IF and Video Amplifier Characteristics

		REFERENCES	
QUESTION NO.	CORRECT ANSWER	Narrative Ref. Pages	P.I. Ref. Frames
1.	b.	46	1-8
2.	c.	47	1-8
3.	c.	47	1-8
4.	b.	48	1-8
5.	a.	49	9-16
6.	d.	48	1-8
7.	b.	48	1-8
8.	a.	47, 48	1-8
9.	d.	50-51	17-24
10.	b.	51	17-24
11.	c.	52	17-24
12.	a.	52, 53	17-24

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 2

RF Amplifiers

		REFERENCES	
QUESTION NO.	CORRECT ANSWER	Narrative Ref. Pages	P.I. Ref. Frames
1.	3.	128, 131	1-6
2.	1.	129, 130	7-11
3.	4.	129, 130	7-11
4.	3.	132	12-20
5.	2.	135	12-20
6.	4.	136	12-20
7.	10	136	12-20
8.	2.	137	21-29
9.	2.	139	21-29
10.	B	141	30-36
11.	AB	141	30-36
12.	A	141	30-36
13.	4.	143	37-41
14.	3.	144	37-41
15.	1.	144	37-41

ANSWER SHEET
FOR
JOB PROGRAM
LESSON 2

Sweep Generators and RF Amplifiers

6. a. No vertical line. disappeared.

8. a. No sweep voltage. disappeared.

12. a. Increased

16. a. Increased

24. a. 5.

25. a. 5.
    b. 500 kHz
    c. 6
    d. No
    e. Yes

27. a. 500 kHz
    b. 0 to 1 MHz
    c. 1 MHz

36. 2.8 V; 2 V

37. 2 V
37. a. Yes
37. b. Yes

46. a. 22
    b. 95.4 to 99.8 MHz
    c. 4.4 MHz

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 3

IF Amplifiers

QUESTION NO.	CORRECT ANSWER	REFERENCES	
		Narrative Ref. Pages	P.I. Ref. Frames
1.	3.	199	1-7
2.	1.	201	1-7
3.	1.	200	1-7
4.	2.	203	8-14
5.	2.	203	8-14
6.	4.	204	15-24
7.	3.	205, 207	15-24
8.	2.	209	15-24
9.	4.	209	15-24
10.	2.	211	25-28

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 4

Video Amplifiers

		REFERENCES	
QUESTION NO.	CORRECT ANSWER	Narrative Ref. Pages	P.I. Ref. Frames
1.	increased, coupling capacitor	274	1-8
2.	c. the loss of high frequency amplification	276	9-16
3.			
4.	C1, R2	275	1-8
5.	L1, L2	277,279	9-16
6.	c. R2	275	1-8
7.	L2	279	9-16
8.	L1, L3	283	17-21
9.	a. R7, R8, and R9	282	17-21
10.	R4, C5	283	17-21
	a. good, good	286	22-28

ANSWER SHEET
FOR
JOB PROGRAM
LESSON 4

Video Amplifiers

7. .18 V P/P

8a. .22 V P/P
  b. 1.22
  c. Unbypassed emitter resistor

12a. Increased
  b. Decreased

19a. Decreased

25a. 22.6
  b. 26.4